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Marauder!

How the Martin B-26 Hit the Beach on D-Day

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o Have A Mason-Dixon Line
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mention that the '94 Suburban is big enough to seat nine passengers? Did we mention they'll be able to luxuriate in available custom leather seating surfaces? Or that Suburban can stow up to 149.5 cubic feet of "stuff" in its cargo space? We hope we didn't overlook anything. Then again, the '94 Suburban is pretty hard to overlook.

Chevy Suburban
LIKE A ROCK

June/July 1994
Volume 9, Number 2

AIR&SPACE
Smithsonian

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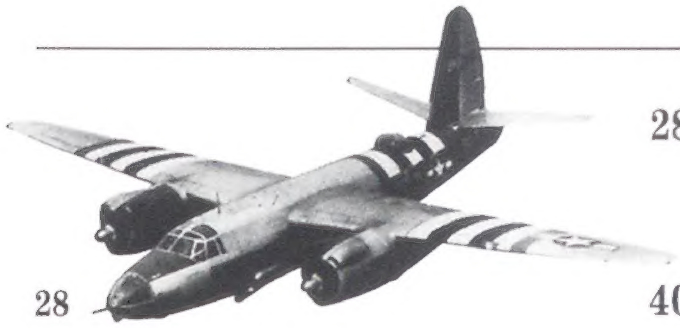
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Cover: B-26 Marauders fly over France in June 1944 in a photograph from the National Air and Space Museum.

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FLYING EXCELLENCE: ROLEX AND THE EAGLES
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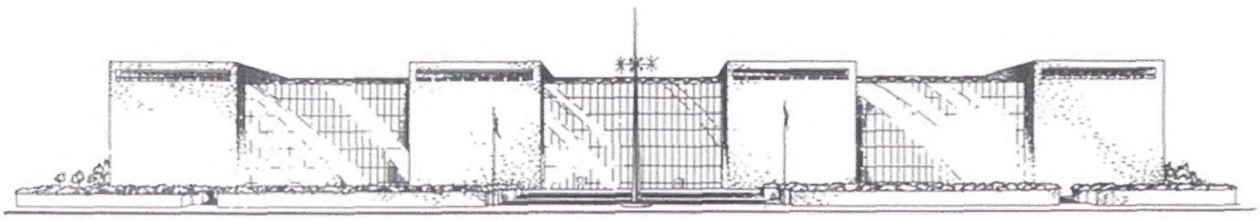
VIEWPORT



Listening Out

A tantalizing scientific search with incalculable potential is now being privately funded because of lack of public support. It is the quest for intelligible messages that might be reaching us from other civilizations in the universe.

The question to be answered: Are we alone? In this enormous universe, with its hundred billion galaxies each host to a hundred billion suns, could ours be the only solar system housing a population able to communicate with others?

The question has been around for a long time. It was first pondered by the Greek scholar Anaximander of Miletus in the sixth century B.C. A century later, Democritus of Abdera, who developed the atomic theory, hypothesized a cosmos in which other suns, moons, and populated earths existed in infinite numbers.

The debate has continued for 25 centuries, constituting one of the longest lasting controversies. In the year 1600, the Church went so far as to burn the Italian scholar Giordano Bruno at the stake for advocating, among other heresies, the existence of civilizations on other worlds.

All these centuries it looked as though there would never be a way of telling whether we on Earth are unique. Then around 1960 a strategy for a systematic search began to emerge. In the United States, Frank Drake, Philip Morrison, and Giuseppe Cocconi pioneered the way. In the Soviet Union, it was I.S. Shklovskii, whose book Carl Sagan translated, expanded, and popularized in the West.

Two trends emerged. One was to search for chemical evidence of life by analyzing the spectrum of radiation from distant astronomical sources. By those means scientists might detect the coexistence of such by-products of life as oxygen and methane, a first clue to be followed up with greater scrutiny. The second thrust was to search for signs of messages that intelligent beings might be transmitting across the vast spaces separating stars.

This Search for Extraterrestrial Intelligence—SETI—was to be a systematic process. It would restrict itself to regions of our Milky Way galaxy. All other sources are at least ten times farther away, their radiation a hundred times fainter.

The search would also be restricted to the radio frequency band. In contrast to visible light, which is strongly absorbed by dense clouds of interstellar dust, radio waves readily stream across the entire Milky Way. But even within the radio domain there are preferred frequency bands that are exceptionally clear of disturbance because there are no naturally occurring emissions of radiation that would add distracting noise to transmitted signals.

We already know that a radio message beamed out by the world's largest radio antenna, at Arecibo, Puerto Rico, could be detected by a receiver of the same size all the way across the Milky Way, 60,000 light-years away. That takes the potential detection of such signals out of the realm of science fiction and makes it a distinct possibility.

While smaller searches had been going on before the current decade, in October 1992 NASA initiated and funded the first systematic search. Then, less than a year later, just as the search was hitting its stride, Congress eliminated the funding from NASA's budget, stopping the effort.

To find a way for the search to continue, SETI chief scientist Jill Tarter and the nonprofit SETI Institute in Mountain View, California, sought out William Hewlett and David Packard, co-founders of Hewlett-Packard; Gordon Moore, co-founder of Intel; Paul Allen, co-founder of Microsoft; and other technologically astute contributors, who donated several million dollars to continue that search.

This has given SETI a temporary reprieve, but long-term funding remains problematic. The importance of the project appears to justify steadfast support and renewed public backing.

—Martin Harwit is the director of the National Air and Space Museum.

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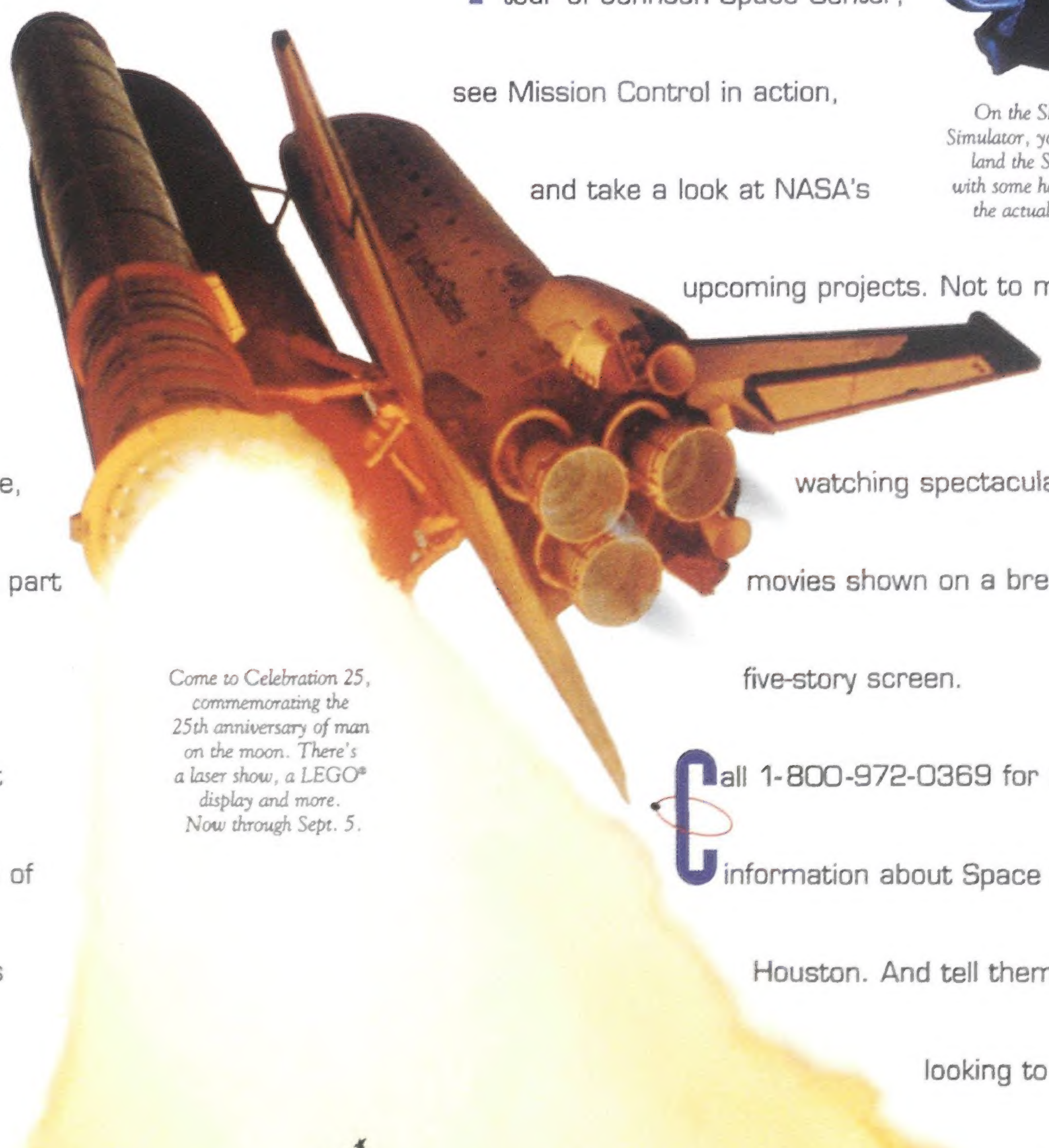

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LETTERS

Bad Memories

After reading "The Search for the *Challenger*" (Above & Beyond, April/May 1994), I was left searching for some redeeming reason why you would publish such gratuitous details about the fate of the *Challenger* crew. The story adds nothing to our memories of the astronauts and will most likely be a painful reminder for those family members and friends who see it.

—Ted Krempa
Oceanside, California

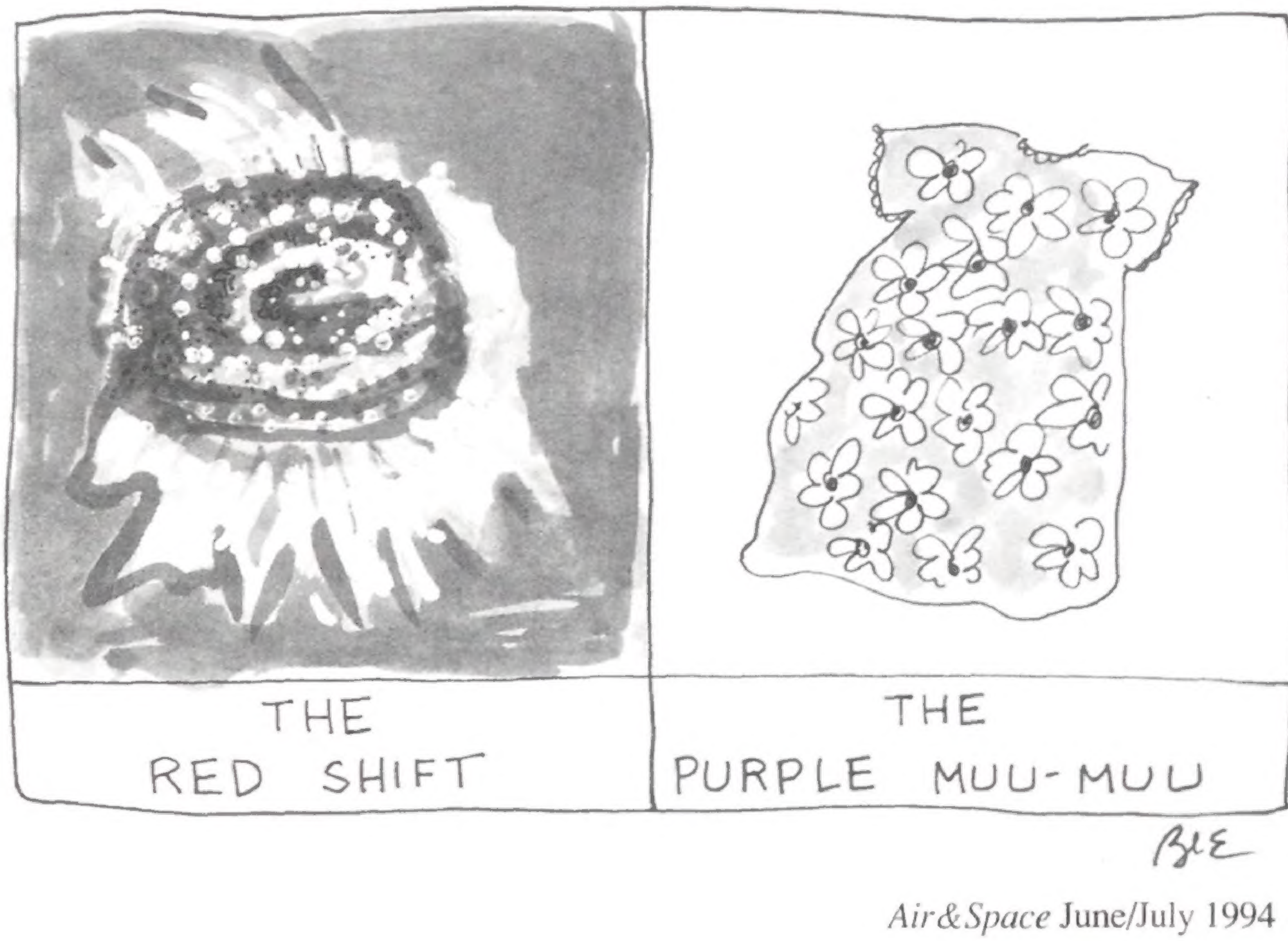
Glenn Arnett's story reminded me that the search for the *Challenger* flight deck was, as far as I can see, unnecessarily arduous.

Back in the 1960s, the radars at Cape Kennedy used a classified tracking software program called In-Line Integration Control (ILIC). The program integrated the higher derivatives of the tracked object's velocity vector to predict future location and pointed the sensors so that there was essentially no error signal. The result was a high degree of precision and real-time location information. The coordinates of the objects were displayed on a video screen, along with the TV image of the objects. You may recall the images of the Apollo launches, smoothly tracked by a telescope several miles from the radar that pointed it.

During one classified test, a missile (a Poseidon, I think) blew up, and seven pieces were tracked as they fell into the ocean. Because exact coordinates were available for each impact location, divers recovered all seven pieces the same day.

When the *Challenger* blew up and the flight deck couldn't be located, I called the engineer in charge of range instrumentation at the Cape and asked why ILIC hadn't tracked it. He told me that when NASA had changed operating contractors on the range, the new contractor "improved" the tracking software and that it didn't have the bandwidth it used to. I made a lot more calls, trying to find out if anyone had a copy of ILIC, and everyone gave me the same answer: "They make us clean out our safes; my copy was destroyed years ago. Everything over five years old goes."

It appears that Glenn Arnett and hundreds of others might have been



spared the effort of searching for the *Challenger* had bureaucrats not been obsessive about destroying classified material, and contracting officers selected a bidder with a bit more common sense.

—Major Erik S. Buck
U.S. Air Force (ret.)
Dayton, Ohio

Another Rude Awakening

Boise City, Oklahoma, was not the only town in the United States that was bombed in the summer of 1943 (Flights & Fancy, April/May 1994). At 4:15 in the morning on August 16, six 100-pound sand-filled practice bombs struck Tarnov, Nebraska. The bombs had no doubt been released by a bombardier who had mistaken the town's streetlights for the light at a practice range nearby. One bomb struck a home, plummeting through the roof, a wall, and a pantry before coming to rest in the basement.

The citizens of Tarnov plan on celebrating the bombing this summer, perhaps even having a plaque made commemorating the event.

—Robert L. Carlisle
Norfolk, Nebraska

The Trouble With NASA

A chill ran down my spine as I read "Gravity's Overdrive" (February/March 1994). Like Michael Minovitch, I came to NASA as a graduate student, hoping to make "the big time" as a government employee. From my experience, both as a graduate student and as a contractor, I can tell you that the reason Minovitch's work on the gravity assist never had the necessary tools, funding, recognition, or influence is simply that Minovitch never had a NASA badge. Any paper that gets written by a contractor always bears the name of the NASA employee overseeing him or her, usually as the first author. More than once, I have witnessed a contractor present a paper at a convention, then heard a NASA principal investigator say, "Oh yeah, that was my idea. I just let the contractor develop it."

I think Minovitch deserves all possible

credit for his ingenious work. As for his personality, anyone is likely to be a little irritable when his idea is appropriated by people who never properly funded or even understood it in the first place.

—Name withheld by request

The Mysteriously Missing Engines

The graphic supplement on the Lockheed Skunk Works (April/May 1994) was fascinating. However, it describes the JetStar as a twin-engine jet. I thought the original was powered by four turbojets.

—Charles Hansen
Tinton Falls, New Jersey

Editors' reply: The first two prototypes each used two Bristol Orpheus turbojets. However, production models did employ four Pratt & Whitney JT12As.

More on Captain Stewart

In my opinion, "The November Oscar Incident" (February/March 1994) comes down to one overriding factor: lack of fuel. Had Captain Stewart added perhaps 15,000 pounds, he might never have felt forced to attempt a life-or-death landing. He could have established the airplane on the localizer and intercepted the glide path from below, as the autopilot requires. And if he still missed the approach, he could have flown to his alternate airport.

Because excess fuel sometimes has to be burned off before landing, airline managers have brainwashed crews about fuel conservation to the point that a captain is made to feel ashamed of adding fuel. At the peak of my career as an airline pilot, I was denied extra fuel I deemed necessary for one leg. The company claimed there was a fuel shortage at the airport, which I believed was a bare-faced lie. I refused to depart and was subsequently relieved, then punished by being relegated to the right seat for 30 days.

UNIDENTIFIED FLYING OBJECT

Can you identify this aircraft? From time to time the National Air and Space Museum receives photographs of objects that its archivists cannot identify. The staff would like to learn more about this British monoplane—possibly a Blériot XI type—and the event that drew so many admirers. They believe the photograph dates back to around 1909 to 1913. If you can solve the mystery, write to Letters, Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024; via e-mail (America On Line):* airspacedt. *Please type or print clearly, and include your daytime phone number.*

Recent UFOs have brought some tantalizing leads but no conclusive identifications as yet. Among the most promising possibilities that the archivists are checking out: John H. Uyeno believes that the February/March 1994 UFO, the Mono-Dirigible, was designed and built by French industrialist Andre Citroen in 1932. Morris Silberberg, on the other hand, says he saw the vehicle—a truck decked out to look like an aircraft—in 1928, and that it was owned by the Bronx Flying Club. As for the December 1993/January 1994 UFO, it may be a powered glider produced by the Opel company of Germany, according to John Brierley. In addition, Isolde Baur, the widow of Messerschmitt test pilot Karl Baur, believes the second man from the left is glider pilot Wolf Hirth and the man in the cockpit is renowned aircraft designer Alexander M. Lippisch.

My advice to other airline pilots is this: fly with your butt covered, and if you get into trouble, even for the sake of the stockholders' profits, don't expect the company to bail you out.

—Edward J. Toner Jr.
Howell, New Jersey

Glitchophobia

"The Big Balloon" (April/May 1994) was an excellent study of how space projects used to be accomplished, and how they should be accomplished again: test, evaluate, test again, then repeat until you get it right.

Unfortunately, nowadays we have only one shot at pulling off a project. At the first sign of trouble or failure, the plug is pulled. No one is allowed to break anything, even though that is usually the best way to learn new lessons. An excellent case in point seems to be the DC-X program. Though the first two test flights were successful, the third almost ended in disaster: one of the four engines was slow coming up to thrust, causing the rocket to come off the pad sideways. Excellent design, engineering, and software saved the flight, and the rocket hit the planned altitude right to the second. Shortly thereafter the program ran out of money.

Now the Pentagon has the funding to complete the flight testing but won't release it. I believe the real reason is that the near-failure has made the military afraid to take chances on further tests.

Getting back to "The Big Balloon," I want to correct the assertion that the Galileo space probe's antenna had never been tested in space at all. Actually, the antenna is identical to numerous antennas that have been successfully used on the Tracking and Data Relay Satellite System, which has been in space for more than 10 years. Galileo's problems probably stem from the fact that lubrication needed to deploy the antenna was lost due to the heat it encountered during the Venus flyby. The spacecraft was never meant to handle such high temperatures.

—Larry Evans
Mach 25 Communications
Lake Forest, California

Pre-Posthaste

The postcards reproduced in "Posthaste" (Oldies & Oddities, December 1993/January 1994) bear the claim "first American rocket airplane flight." However, two years before the flight of the mail-carrying Gloria rockets, William Swan flew the Steel Pier Rocket Plane, a glider powered by 12 solid-fuel rockets, to an altitude of 200 feet over Atlantic City, New Jersey.

—Ron Miller
King George, Virginia

REUNION ALERT

459th Bombardment Group (Heavy). 12th reunion; open to all who served in the 459th and associated support units during World War II. Sept. 15–18, 1994, Holiday Inn Convention Centre, Omaha, NE. Contact Al Dhaenens, (402) 455-7325, or John Devney, (716) 381-6174.

368th Fighter Group (World War II). Oct. 13–16, 1994, Campbell House Inn, Lexington, KY. Contact Randolph Goulding, (404) 455-8555.

Send correspondence to Letters, Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024; via e-mail (America On Line):* airspacedt. *Please type or print clearly, and include your daytime phone number. Letters will be edited for publication.* Air & Space *is not responsible for the return of unsolicited photographs or other materials.*

Flowers for the *Titanic*

Coast Guard chaplain John K. Carter stood harnessed to his pulpit aboard the Lockheed HC-130H transport, his prayer cloth tossed by the wind while he waited a few feet from the open cargo ramp. As the craft approached the site where the *Titanic* sank in 1912 after striking an iceberg, Carter, head bowed and hands clasping a small book of prayers, spoke his words to the wave tops of the North Atlantic 500 feet below.

The only sound aboard the aircraft was the wind and the relentless drone of the turboprops. It was dark and mysterious here under the low-lying clouds last April 15, the 82nd anniversary of the disaster. Loadmasters Paul Holland and Steve McDyer stood with the chaplain, each holding a wreath of red and white carnations. When the transport reached exactly 50° 14′ latitude and 41° 46 longitude, the wreaths became a spray of flowers in the slipstream, then splashes of color in the slate-colored sea.

JOHN SOTHAM

The horizon tilted as the airplane circled for another pass. This time, the men released a wreath-draped container that held the remains of Ruth Becker Blanchard, a *Titanic* survivor who was just 12 years old on the night of April 14, 1912. Blanchard's family felt she would want to be buried at sea where the *Titanic* went down and arranged for the ceremony with the Coast Guard and the Titanic Historical Society. "As I was standing there, I couldn't help looking at the sea itself, and I imagined the horror of that situation, knowing how large the sea is and how cold it was," Carter said of the historic sinking. "Also, I was concerned that Mrs. Blanchard received as dignified a service as possible."

After the ramp closed with a hydraulic whine, the aircraft climbed back through the clouds to 6,000 feet, and it was back to work for the men of Coast Guard 1503. Every year, Coast Guard fliers from Elizabeth City, North Carolina, and members of the International Ice Patrol deploy to St. John's, Newfoundland, to search for the icebergs that break off Greenland's glaciers and drift into North Atlantic shipping lanes. The Coast Guard has managed and operated the patrol since 1914, after the *Titanic* demonstrated the need for such a service.

The primary aircraft used is the HC-130H Hercules, which employs both side-looking and forward-looking radar to detect the icebergs and ice floes that menace the area. Since radar returns can be deceiving, however, a closer look is sometimes called for. Observers sit at large windows on both sides of the aircraft and record the size, shape, and position of bergs they see. Both radar and visual information is entered into a computer at the operations center in Groton, Connecticut, which plots the positions of ice and predicts movement based on years of experience with the weather and currents. The data is transmitted to sailors, who can listen to an "Ice Bulletin" every 12 hours or receive a radio facsimile chart of known and predicted ice hazards. A computer's

prediction is not enough to stake lives on, however. "We need to know what's happening today," says patroller David Kennedy. "You can't predict this year's icebergs on last year's currents. That's why we have to update constantly."

One of the patrol's biggest challenges occurs when warm Gulf Stream currents encounter the cold northern air around Newfoundland. The resulting dense fog, icing conditions, and violent thunderstorms are constant threats. "The weather here is atrocious about 80 percent of the time," says veteran patroller Andy Hampton.

The burial at sea and wreath laying were all the more poignant since they were performed by the group responsible for saving lives at sea since the *Titanic* sank. "When the chaplain's voice came on I just stopped and said, 'You know, I'm really proud to be here,' " said pilot Dan Rocco. "Later, a lot of the crew said they were a little choked up."

—*John Sotham*

UPDATE

Pulsar's Planets, Ida's Moon

After studying an additional three years' worth of evidence, Pennsylvania State University astronomer Alexander Wolszczan announced in the April 22 issue of *Science* that radiotelescope data has confirmed that at least three planets are orbiting a pulsar in the Virgo constellation ("The Planet Hunters," October/November 1992). Wolszczan's first announcement, in a 1992 issue of *Nature*, was met with skepticism, but many in the scientific community now seem convinced.

After studying a photo of asteroid Ida taken last August by the Galileo spacecraft en route to Jupiter ("On the Road to Io," December 1988/January 1989), Galileo project teams have detected a tiny moon orbiting the asteroid at 60 miles. The debate over its origin will continue until the spacecraft sends more data.

Speed's Nemesis

STEPHAN WILKINSON

Last March the National Aeronautics Association held its annual awards ceremony at the Smithsonian's National Air and Space Museum to honor the 10 most noteworthy national and world aviation records established by Americans in 1993. The awards ranged from the silly (Fastest Time to Visit All the Hard Surface, Public Airports in Michigan) to the sublime (Great Circle Distance Without Landing).

One eminently praiseworthy speed record fell to a tiny needle-nosed single-place airplane that rarely gets more than 150 feet above the ground, flies largely in circles, and never travels more than 10 miles from its starting point. That airplane is *Nemesis,* a Formula One pylon racer owned, flown, and in part built by Lockheed aeronautical engineer Jon Sharp.

The Formula One category is restricted to airplanes powered by Continental C90 or 0-200 four-cylinder engines with fixed-pitch or ground-adjustable propellers, an empty weight of at least 500 pounds, and a minimum wing area of 66 square feet. Despite these limitations, *Nemesis* is the fastest four-cylinder vehicle in the world. Last August it set the three-kilometer speed record for its class—277.26 mph—and the airplane routinely wins races at speeds of 255 or more. Yet Sharp says he's already designing "an airplane to beat this one. We haven't cut any material yet, but we have some ideas."

Unless his competitors move quickly, Sharp's team will own Formula One racing for some time to come. "People are finally starting to look seriously at what we've done, but it's taken a while," Sharp says. Wing designer Dan Bond agrees. "The wing is a radical departure. The thick and unusual shape is characteristic of NASA NLF [natural laminar flow] sections, and when the aircraft first rolled out, racers were convinced it would never work. The wing is twice as thick as what they're used to."

The rest of *Nemesis* looks much like a classic Formula One design—voluptuous Dolly Parton engine cowling with each blister housing two cylinders, cockpit canopy just big enough for a crash helmet, tiny tail surfaces—but the airplane is a state-of-the-art fox in a chicken coop largely filled with square-wing tube-and-fabric classics. *Nemesis* is constructed entirely of carbon-fiber composite. Its structure is so stiff that if you tap a wingtip or jiggle a horizontal stabilizer, you'll think the airframe had been milled from a single ingot. There is no give. Riding the airplane through round-the-pylons turbulence must be like racing an oxcart on cobblestones.

Other Formula One racers assiduously tape over airframe seams and discontinuities, hoping to smooth the airflow. *Nemesis* has no seams worth taping. The entire structure forward of the cockpit rear bulkhead is, with the exception of the ailerons, canopy, and cowling, a single piece. The wings, fuselage center section, landing gear legs, and even wheelpants are built as one seamless unit. For every annual inspection, Sharp must saw the wheelpants off to allow the tires and brakes to be checked, then mold new pants in place.

Cockpit accommodations are equally austere. There is no seat, no cushion, no parachute. Sharp sits directly on the bottom skin of the fuselage, facing a minimal display of instruments—G-meter, oil temperature and pressure, tachometer, and a sensitive two-needle airspeed indicator. The controls are conventional rudder pedals, a side-stick controller for the right hand, and throttle and mixture on the left. "The throttle is essentially a switch, either full on or off," says Dan Bond, "but Jon adjusts the mixture constantly as the engine temperature changes during the race. We run at 4,000 to 4,500 rpm, and the closer we can get to 4,500 the better we like it."

Sharp uses a variation of a race technique developed in the 1920s by Jimmy Doolittle, first with his Curtiss R3C Schneider Cup racers and then with the Gee Bee. While others dashed down the straights and wrapped tightly around each pylon, trading speed for Gs, Doolittle used his speed advantage to fly a long, gentle, and wide circuit. Sharp does much the same thing. Good sports car racers also use this technique—smooth into the corner and fast out is better than scrubbing

away all your speed with late braking and a scramble for the apex.

Certainly some of *Nemesis*' speed comes from careful attention to reducing cooling drag. (On every airplane, air to cool the engine must be routed in and out of the airframe, which creates drag.) Jeff Corbin, a pit crewman with a Miller Special team, says, "You used to rarely get to see the airplane with the cowling off." But at the Phoenix air races last March, Sharp and his team hid nothing. Perhaps that was because, as Corbin puts it, "even someone who knows what they're looking at could take a close look at *Nemesis* and still not know how they do it."

"We could fly with the whole top cowling off and the engine would cool just as well," Sharp says. "Cooling drag is the major area where I think homebuilt designers could make improvements too. General aviation manufacturers just squashed the ant with a sledgehammer when they approached engine cooling, and homebuilt designers generally emulate them."

Sharp hopes to find sponsorship to compete in France next year in the international grand prix for Formula Ones. "The best European airplanes are running 230 to 240 mph," Bond points out, so the *Nemesis* team will make the journey with considerable confidence. If Sharp flies his usual faultless heats and final race, air racing Over There will never be the same. And the French, so intent on stemming the incursion of English, will merely have to style the airplane *Némésis* to assure political correctness.

—Stephan Wilkinson

UPDATE

Strung Along

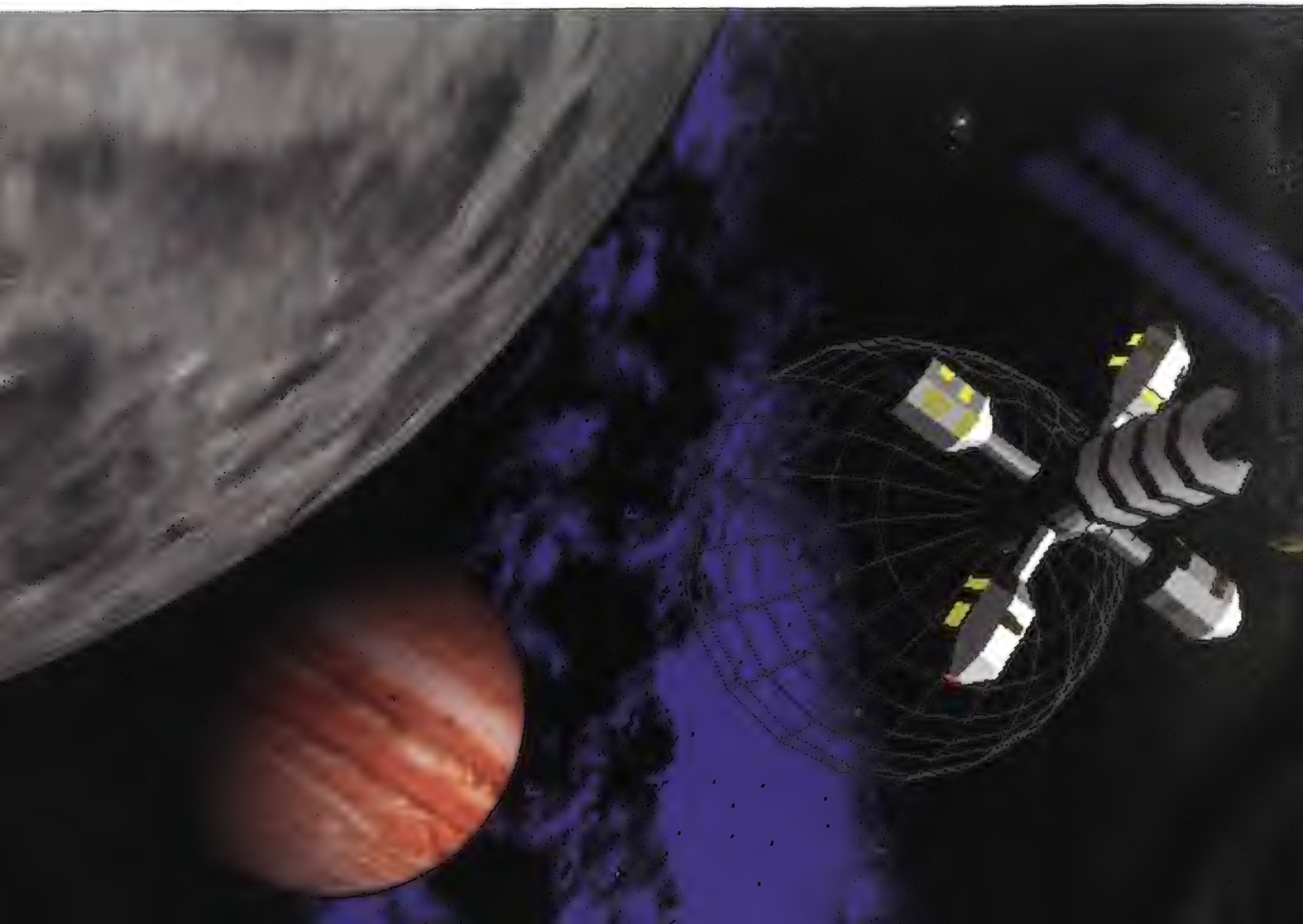
NASA's tethered-satellite research scored a success last March when a 50-pound payload was deployed from a Delta 2 launcher upper stage on a 12-mile-long plastic string (Oldies & Oddities, June/July 1992). The tether, about as thin as dental floss and orbiting at 215 miles up, could be seen with the naked eye from the southern latitudes when the sun illuminated it. However, only some six miles of the tether remain after it apparently ran afoul of a meteorite.

Once More, With Feeling

The rollout of Boeing's new wide-body 777 airliner last April at the company's Everett, Washington plant blended Hollywood, Broadway, and the ambiance of a disco. Not surprising, considering that Dick Clark Corporate Productions had choreographed it all.

The rollout ceremony was repeated 15 times to accommodate the crowd of 100,000, including Secretary of Transportation Federico Peña, Federal Aviation Administrator David Hinson, and representatives from some of the world's largest airlines. But the party was really for Boeing employees and their guests, who kept arriving on shuttle buses for a solid 15 hours.

The rollout was a logistical triumph nearly equalling the creation of its cause ("You Can Look But You Can't Touch," April/May 1994). Some 3,000 volunteers rode herd on the crowd at what Boeing spokesperson Barbara Murphy called "the largest rollout the industry has seen." Each hour some 7,000 guests were ushered into a cavernous hangar where rock music blared and the 777 logo swirled overhead in a light show. Suddenly all went dark and a booming orchestral score signalled the start of the show. A huge curtain rose to reveal the aircraft in sil-



houette. Its lights were switched on one by one, with external spotlights illuminating the exterior. Beige-jacketed ushers, wielding lighted paddles like those used to guide airplanes to their gates, summoned the crowd to the airplane for a closer look. As guests left, they were handed nylon lunch bags bearing the 777 logo and stuffed with snacks. Even this was timed to the minute: volunteers were drilled to distribute one bag every five seconds.

What was the cost? Boeing wouldn't say. "We wanted an event that was memorable, meaningful, and repeatable," Murphy said. "When you consider the cost per person, we felt it was very cost-effective." Yes, but can you dance to it?

—Rita Cipalla

BOEING

UPDATE

Have Gun, Will Really Travel

Scientists at Sandia National Laboratory in Albuquerque, New Mexico, have fired a tiny metal plate weighing a fraction of an ounce to a speed of 10 miles per second, or 36,000 mph, with the facility's 60-foot multi-stage light-gas gun ("Battle of the Big Shots," August/September 1993). Project manager Lalit Chhabildas says that with a shock-softening "pillow" in the gun's second piston, the hypervelocity launcher may achieve 11 miles a second (39,600 mph). The tests are part of a research program on the effect of space debris on orbital structures.

Apollo Celebrates Apollo

On July 20, 1969, a group of Pennsylvania firemen planted an American flag on Moon and returned home with Moon soil. A few hours later a similar scene was played out a quarter of a million miles away, when astronauts Neil Armstrong and Buzz Aldrin planted the U.S. flag on the lunar surface.

The Apollo 11 mission not only ushered in the first true moonwalk, it also gave the residents of Apollo, Pennsylvania, a reason to celebrate. When Apollo mayor Duane Guthrie dispatched a cadre of firefighters to the nearby township of Moon, he launched an annual salute that continues to this day. Never mind that Apollo had absolutely nothing to do with the Apollo program. "The name is the same," says lifelong resident Dale Morgan. "Besides, Apollo is in Armstrong County, and Neil Armstrong was the first man to walk on the moon. We thought we ought to put on a celebration."

While Moon, Kentucky, has mustered only a single Apollo 11 jubilee to date and Armstrong's hometown, Wapakoneta, Ohio, celebrates the event every five years, Apollo, Pennsylvania, has hosted a week-long moon landing festival every year since 1969. This July, to honor the 25th anniversary, the town is planning an extravaganza, at least as small-town celebrations go. Highlights will include carnival rides, fireworks, and a parade featuring men from Mars (Pennsylvania).

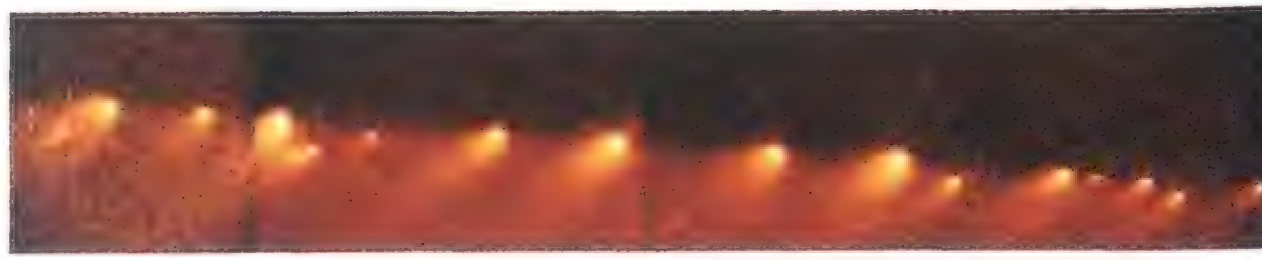
The festival is orchestrated by the volunteer firemen of Apollo Hose Company No. 2, an organization that doesn't have

much clout when it comes to securing engagements with Apollo astronauts or other NASA dignitaries. "We'd like to get an astronaut here, but NASA's got its own 25th anniversary celebrations planned," says parade chairman Tom Coulter. "We can't compete with the big festivals in Washington, D.C., or Houston, but at least we should get an E for effort."

A mainstay of the celebration has been a light show featuring fireworks-studded replicas of Apollo spacecraft. "We have the whole thing—the actual moon landing—in pyrotechnics," says Morgan. A rocket blasts off and rises several feet, and a lunar module descends from a football stadium light stand. At touchdown, sputtering signs proclaim "The Eagle has landed" and "One small step for man," and technicians ignite a "dazzling display of an astronaut holding a flag," says Morgan. "It really brings down the house." At this year's festival, Moon men will repay the visit they received 25 years ago from Apollo ambassadors. "Basically, we're going to swap dirt again," says Coulter. But the nostalgia of these antics can't match the suspense of 1969. "I remember how we all watched Neil Armstrong climb down the ladder," Coulter says. "That was a *real* thrill."

—Victoria L. Contie

SPACE TELESCOPE SCIENCE INSTITUTE



The Great Crash of '94

What wiped out the dinosaurs and their friends and foes 65 million years ago? A comet or asteroid slamming into Earth? A good way to test that idea would be to observe how a planet's atmosphere responds to a violent impact. Happily, this opportunity will be offered to astronomers between July 16 and 22, when more than 20 fragments of Comet Shoemaker-Levy 9 smash head-on into Jupiter.

According to Donald Yeomans of the Jet Propulsion Laboratory in Pasadena, who recently addressed a meeting of the American Astronomical Society in Washington, D.C., Shoemaker-Levy ventured into Jupiter's clutches as long ago as 1850. Since then it has been trapped in a Jovian orbit, but in 1992 it strayed too close and was torn apart by the giant planet's gravity field. The timetable for the collisions of the resulting fragments, several of them nearly two and a half miles across, has been closely reckoned, and virtually every telescope on Earth will be pointed at Jupiter from mid- to late July.

The fact that the impacts will occur on the dark side of Jupiter—the side not seen from Earth—does not deter watchers. The fireballs produced by each impact may be bright enough to momentarily light up the larger Jovian moons, and the reflections of the flashes may be detected by sensitive equipment attached to large telescopes.

Harold Weaver of the Space Telescope Science Institute in Baltimore plans to look very closely at what happens. Based on his best estimate of the sizes of the comet fragments and the likely energy of each impact, he predicts that the combined blasts will be in the 100 million-megaton (TNT equivalent) range. That's similar to the energy of the impact believed to have triggered the mass extinction. In other words, Jupiter is about to receive a dose of energy the likes of which would immediately devastate most lifeforms if it were to happen here.

The impact areas will rotate into our field of view within 30 minutes of the initial fireball, and according to Reta Beebe of New Mexico State University, the ejecta associated with each fireball may remain visible for up to three hours as it falls back into the stratosphere. Although no one expects to see much with a typical small telescope, that will not deter thousands of amateur astronomers. Only after the last of the comet's remains have disintegrated in Jupiter's cloud layers will anyone know whose theories come closest to the truth.

—Gerrit L. Verschuur

UPDATE

LEONARD WEINSTEIN PHOTO

Using a unique telescopic camera and film system, a researcher at NASA's Langley center has taken the first Schlieren photograph of an aircraft creating supersonic shock waves ("Mach 1: Assaulting the Barrier," December 1990/January 1991). The T-38 was flying at Mach 1.1 at 13,700 feet, some six miles from the camera on Assateague Island, Maryland, last December when Leonard Weinstein captured this image using a telescope, a camera with a stationary slit in lieu of a focal plane shutter, a film speed synchronized to the speed of the aircraft, and the edge of the sun as a light source.

UPDATE

People in Glass Houses...

Two Biospherians were arrested last April and charged with burglary, trespassing, and criminal damage to their former residence ("Trouble in Paradise," December 1991/January 1992). Abigail Alling and Mark Van Thillo, who claim they smashed some of the dome's glass panes for the "safety" of the current occupants, say they felt compelled to act after Biosphere bankroller Ed Bass, citing bad management and unprofessional behavior, barred five of the enterprise's original managers from the premises.

Oil Drill

When there's a fire anywhere in the United States, the fire department is on the scene within minutes. But the response to oil spills has been more like what you might expect from a cable installer. When the *Exxon Valdez* struck a reef and dumped 11 million gallons of oil into Alaska's Prince William Sound in March 1989, the company's response was widely regarded as too little too late.

These delays may become mercifully rarer, if an exercise off the coast of Houston, Texas, last March is any indication. The test brought together the U.S. Air Force, the Coast Guard, and the Marine Spill Response Corporation (MSRC), a company formed in 1990 by a group of 80 oil companies. The dry run (it was wet, actually) was intended to serve as a model for future rapid response drills.

An Air Force Reserve crew provided the "fire truck"—a Lockheed C-130H Hercules equipped with a spray system. The 910th Airlift Group, based in Vienna, Ohio, has been using its 130s mostly to kill mosquitoes, a little-known Air Force mission that dates back to 1973. For the oil spill mission, the spray nozzles were moved from the 130's wingtips to the aft fuselage. With two dozen nozzles on both sides of the airplane, the C-130 can lay down up to 750 gallons of a detergent-like chemical dispersant a minute.

The day before the test, about 20 Air Force, Coast Guard, MSRC, and Texas government officials met for a briefing. A British team with extensive experience in spill operations was on hand to advise the Yanks and to crew an MSRC testbed built around a Shorts 360 twin-turboprop commuter airliner. The 360, which looks like a boxy porpoise, was carrying a powerful Side Looking Airborne Radar (SLAR) and a suite of optical infrared and ultraviolet sensors, along with a Global Positioning System satellite navigation receiver.

The Coast Guard cutter *Knight Island* would position itself as a target, simulating the center of a large spill. After a dry run, the Herc would descend to 150 feet above the water for its upwind spray run. (For this demonstration, the spray would be fresh water.) The MSRC crew in the Shorts would orbit well above the Hercules and radio when the crew should turn the spray on and off (at spray height, the 130 crew would be too close to see an oil slick if there were one).

As the Shorts flew to the test the next morning, the SLAR picked up small oil slicks at up to 20 miles. At three miles, it was able to spot a quantity estimated at less than two and a half gallons. Radar normally sees a lot of reflected noise from the open ocean, and many radars are designed to suppress such "clutter." This SLAR takes advantage of the fact that oil slicks tend to smooth the water's surface, creating an area of lower radar return that shows up on the video display as a dark spot. The ultraviolet sensor analyzes the oil's telltale sheen, giving its composition; the infrared sensor sees heat variations and interprets them as relative thicknesses (oil at the edges of a slick is cool; at the center, warm).¡

Then the Shorts descended, and the cutter, on station, flashed by the window as the airplane entered a pattern about 2,000 feet above the water. Minutes later, the 130, piloted by Lieutenant Colonel Neal Snyder, began a dry run, completing one racetrack pattern around its target. On its next circuit it dropped even lower and for about a minute issued a stream of liquid that paralleled the cutter on its starboard side. After several more runs, the Herk arced away toward the coast, and the Shorts soon followed.

At a debriefing after the test, one Coast Guard official noted, "It was a good idea to hold [this test] here, because the chances of a spill in the Galveston area are high." The port city is a center for trafficking petroleum. The exercise was rated a success. Said one Environmental Protection Agency geologist, "I'm gonna have a brown-bagger for all the emergency response people when I get back home."

—George C. Larson

The Wall of Fame

A daydreaming baseball fan might picture Babe Ruth, Ted Williams, and Nolan Ryan sharing an emerald diamond.

Aviation buffs imagine other collaborations, like the one depicted on nearly 2,000 square feet of wall in the National Air and Space Museum's Jet Aviation gallery. A Messerschmitt Me 262, a North American F-86, and a McDonnell Douglas F-4 all flying together? Now *that's* a dream team.

Painted in 1981 by aviation artist Keith Ferris, "The Evolution of Jet Aviation" features 27 different airplanes cruising through cloudy skies. The Jet Aviation gallery also houses three aircraft, including the XP-80 "Lulu-Belle," as well as cutaway jet engines and many other artifacts, so when the curators decided to trace the development of jets, they had to devise an exhibit that wouldn't take up much floor space. After conferring with Ferris, gallery curator Tim Wooldridge decided that a mural would tell the story effectively. The two men then began the task of deciding which airplanes deserved a spot on Ferris' canvas. "It had to be the first of a basic type of aircraft—the first American and Soviet swept-wing fighters, the F-86 and the MiG-15, are there," says Ferris. "The B-47 was very important because it was the prelude to all those jet transports. The B-52 is not there, and the reason is that the B-47 was the first step and the B-52 is the carry-on to the next stage."

Ferris and Wooldridge thought their list was complete, but then in 1981 Ferris visited the U.S. Air Force Fighter Weapons School at Nellis Air Force Base in Nevada, where he was helping to devise camouflage patterns. One of the school's pilots persuaded him to include the MiG-21, which, though not a first, was then the most widely used combat aircraft in the world and one that the school trained its students to fly against. Yet another mural entry came from a Museum curator who pointed out that the Japanese flew their first jet aircraft, the Nakajima Kikka, in 1945.

As with all his artwork, Ferris meticulously researched all aspects of the mural, even contacting Erich Warsitz, the steely-eyed test pilot shown at the controls of the Heinkel He 178—the world's first jet-powered airplane—for additional details and photos. For each aircraft, Ferris tracked down original paint schemes and markings. Such dedication has made the artist well known to aviation buffs. "Fortresses Under Fire," perhaps his best-known work, hangs in the Museum's World War II gallery.

After finishing his research, Ferris sketched the entire scene, including the location of each aircraft. He made the He 178 appear so close you feel you could touch a wingtip. The rest of the airplanes were staggered toward the horizon. But few viewers will realize how much engineering was required to produce the mural, which is more than just a group of individual representations. Ferris used descriptive geometry to carefully plot the positions of the aircraft and calculate their relative sizes given their distance from each other and the viewer. The farthest airplane, a Tupolev Tu-144, would be over 2,900 feet from someone standing at the back of the gallery. The Boeing 727 and 747 appear to overlap but would actually be flying 870 feet apart. The end result of such precision is a technically correct although improbable spectacle. After all, a Bell P-59 would have a hard time keeping up with a Lockheed SR-71.

"All the airplanes would be seen flying over the Mall and out over the National Gallery of Art," says Ferris. "I have a top-

CAROLINE SHEEN

view drawing that places the airplanes at exactly that distance to the viewer. The 747 would be over the U.S. courthouse, and the two SSTs [a Concorde and a Tu-144] are out over city hall and the D.C. Superior Court. The whole thing was an exercise in trying to maintain those distances."

After completing a scale drawing, Ferris projected outlines of the airplanes onto the wall-mounted canvas, which was chalked with a one-foot grid system that corresponded to the one-inch grid of the scale drawing. Once he was satisfied with their proper positions and relative sizes, he drew the aircraft on the wall with charcoal. Finally he took brush in hand. "The trick in painting it was making sure the values and color receded as the aircraft got further away," he says. "The whites are whiter and the darks are darker on the closer airplanes."

Ferris spent 113 days painting, often atop a hydraulic lift. Because he was involved in several other projects, his wife Peggy set up a desk and typewriter near the mural so she could oversee her husband's business, sometimes handing the phone to him on the lift.

Peggy Ferris also managed the other main distraction: the constant stream of visitors who came to see the artist at work. When Ferris painted his Fortress mural in 1975, the Museum itself was still a year from completion. His work in the jet gallery, however, became a popular stop for tours. "There were almost constant groups of people coming through," says Ferris, "and Peggy was able to entertain those folks." A guest book was kept to record the names of visitors, which included Barbara Bush, Barry Goldwater, Cliff Robertson, Clint Eastwood, and several senators.

Although 27 airplanes in the same place is probably what air traffic controllers see when they toss and turn at night, the mural is an airplane watcher's delight. The painting did, however, have a few detractors, says Ferris. "Some people said, 'How come my airplane isn't there?' But we did a good job in selecting aircraft because we didn't get very many complaints."

—John Sotham

AT THE MOVIES

NASM LOCKHEED

On June 22, Destiny in Space, *a new IMAX film, opens at the Museum's Langley Theater. A cooperative effort by the Museum, the Lockheed Corporation, and NASA, the film features footage of shuttle astronauts repairing the Hubble telescope during their much-heralded mission last December.* Destiny in Space *also looks at robotic exploration of our solar system, as well as the effort to understand how living and working in space affect the human body.*

Our Hiro

CAROLYN RUSSO

Hiroyuki Nagashima, a 35-year-old aerospace engineer from Tokyo, came to the Museum's Paul E. Garber Restoration, Preservation and Storage Facility in October 1993 by a circuitous route, but he never doubted that he'd reach his destination. "I really wanted to work for the Smithsonian," he says.

He'd been engineering motorcycles at Honda when a former professor arranged an introduction that led to a position at the Museum of Flight in Seattle, Washington. While working there to restore a vintage Boeing 247 twin-engine airliner, he met aeronautics curator Robert van der Linden, a visiting Museum lecturer. That led to an introduction to the Museum's collections management chief, Lin Ezell, and a position on the Garber volunteer staff.

And Ezell had just the project for "Hiro": the restoration of the world's only surviving Seiran, a floatplane bomber built by Japan during World War II (see In the Museum, April/May 1991). An unusual aircraft, the Seiran was designed to travel inside the hangar of a submarine, then launch from a catapult atop its deck and fly toward the target. "I knew the Seiran from the time I was young," says Hiro. "I like floatplanes especially, and this one is very beautiful." Only 28 were ever built, and the Museum has found little information about the rare craft in official documents and archives. Which is where Hiro came in.

"About 10 years ago I found a [molded] resin—it's not plastic, it's *resin*—model kit of the Seiran," says Hiro. "I knew it was very rare, so I bought it for my collection." More importantly, inside the kit was a pamphlet that contained reproductions of original photographs and drawings. After World War II, most Japanese aeronautical engineers destroyed their drawings and documents out of fear of what might befall them if American troops found the materials. ("My professor at the university told me how much he regretted that he abandoned his work," Hiro recalls.) But according to the kit's pamphlet, the Seiran's chief designer had kept many of his original drawings.

On a visit home to get his visa prior to starting work at Garber, Hiro stopped by some hobby shops, and at one he noticed yet another of the rare Seiran kits. He never thought to dig out his own kit from family storage because "I thought that everything at the Smithsonian is so perfect. I thought they would have all the information [about the Seiran]." When he got to Washington and learned otherwise, he telephoned a friend in Japan and asked him to buy the kit he'd seen in the store. It was the last one left.

Of all the original material printed in the pamphlet, the most valuable is a photograph of the airplane's instrument panel, an object whose configuration had eluded both curators and restorers. Based on information in the pamphlet, Hiro has completed a painstaking reproduction of the panel, and he's even initiated a search for the Seiran's chief designer through the cooperation of some hobby magazines and enthusiasts back home. (The kit company is located close to the Seiran factory, "so maybe the chief designer is living near there," Hiro conjectures.)

As a volunteer, Hiro's tenure at Garber recently ended, but the esteem in which he's still held is summed up succinctly by shop foreman Bill Reese: "I hated to lose him."

—George C. Larson

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700 Mon.–Sat., 9 a.m.–4 p.m.; TTY: (202) 357-1729.

Summer Hours From June 13 to September 5, the Museum will be open from 10 a.m. to 6:30 p.m.

June 4 Monthly Sky Lecture. Planetary scientist Christopher Chyba discusses the theory that a comet or asteroid explosion caused widespread devastation in Tunguska, Siberia, in 1908. Einstein Planetarium, 9:30 a.m.

Boomeranging on the Mall. Join experts in playing boomerang games (boomerangs will be provided). Free tickets to the event will be handed out in the Museum. Noon to 4 p.m. (rain date June 5).

June 15 Exploring Space Lecture Series. Reta F. Beebe, an astrophysicist from New Mexico State University, will discuss Jupiter's ever-changing atmosphere. Einstein Planetarium, 7:30 p.m.

June 18 Night Sky Workshop for children ages seven to 12. Einstein Planetarium, 9:15 a.m., tickets $6. To register, call (202) 786-2106; TTY: (202) 357-1505.

July 18–22 Actor Kevin Reese presents his one-man play *Apollo to the Moon*, the story of a young astronomer who has always dreamed of journeying to Earth's nearest planetary neighbor. The multimedia program features more than 100 photographs, taped broadcasts from space, and music from the 1960s. Einstein Planetarium, 10 a.m. and 6 p.m.

August 6 Monthly Sky Lecture. Einstein Planetarium director James H. Sharp offers an introduction on the best ways to observe the astronomical splendors of the night sky in summer. Einstein Planetarium, 9:30 a.m.

Live Music The U.S. Navy Commodores, known for their mixture of jazz, swing, and big band sounds, will entertain visitors with free noontime concerts on the Museum's north terrace on July 1, 8, 15, and 22.

Museum Visits For a free planning packet, write Smithsonian Information, Smithsonian Institution, Washington, DC 20560 or call (202) 357-2700. Daytime parking near the museums is limited; visitors are urged to use the Metrorail subway system.

Mr. Marseille

Fresh out of Airborne Radio School, I arrived in France in July of 1956, assigned to the 12th Troop Carrier Squadron, 60th Troop Carrier Wing (Medium), based at Dreux Air Base in Normandy. The primary mission of the wing, equipped with shiny new C-119G aircraft, was combat cargo.

Except in England, European air traffic control was primitive. In North Africa and the Middle East, even radio navigation was mostly nonexistent, with only a few radio compass stations from the early 1930s. There were two Flight Information Regions that had no voice high-frequency capability, Basra in Iraq and Marseille. A few others had limited voice, but because we couldn't count on it, we frequently worked those regions in Morse code.

High-frequency radio (short wave) transmissions don't move along a line of sight but rather follow the curve of the earth and bounce off the stratosphere. They can be transmitted for very long distances, but every receiver on that frequency, however remote, can send or receive. It's a giant party line. Visualize a situation in which, say, 20 aircraft are flying in the FIRs of Rome, Athens, Cairo, Tunis, Lod (Israel), Casablanca and Algiers, along with Ankara and Istanbul, the two stations in Turkey, all using the same frequency. If you know anything at all about citizens' band radio, the word "chaos" will come to mind.

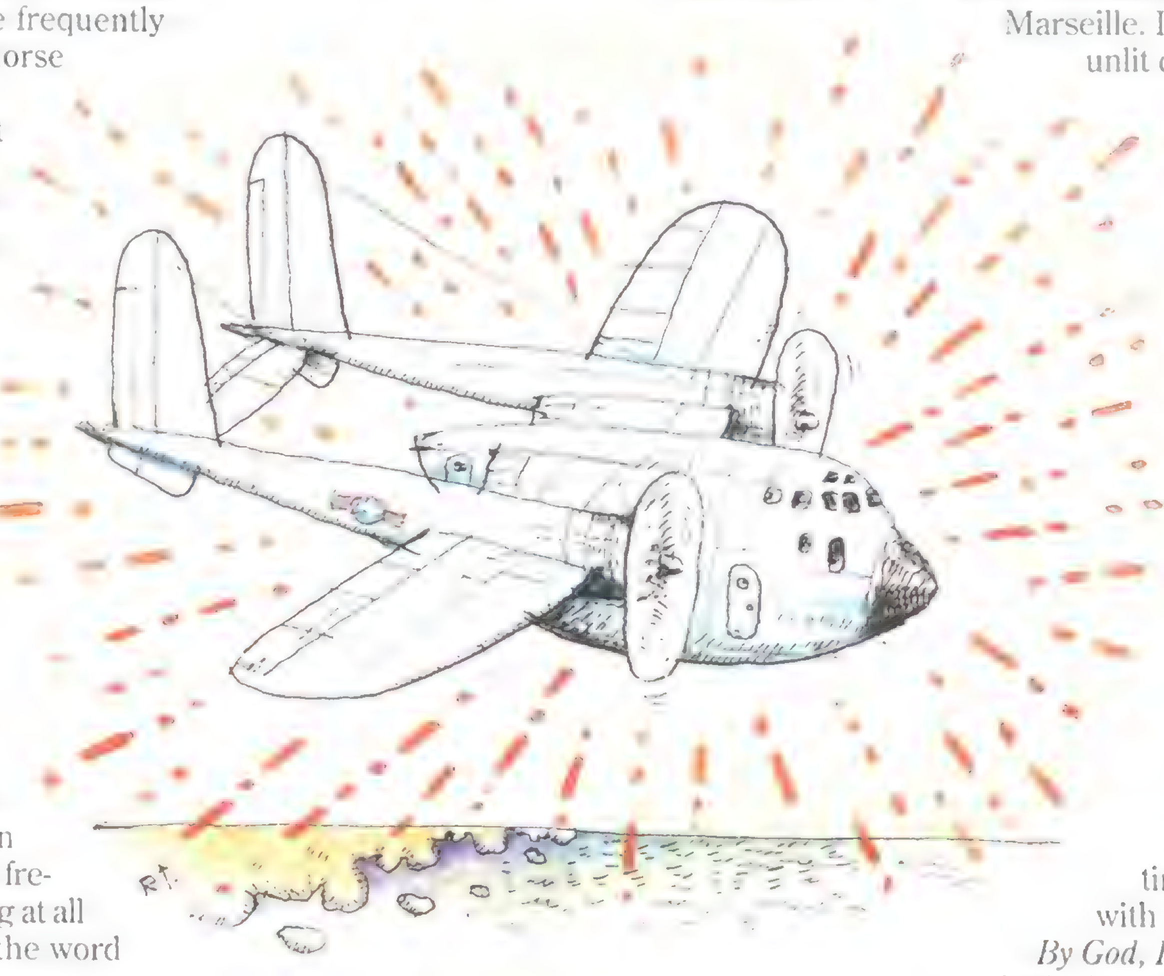
But it wasn't chaotic because we adhered to a mostly outdated principle called radio discipline: Know what you have to say, say it, and GET OFF THE AIR!

My relationship with the FIR controller Mr. Marseille began on my initial training flight en route to Athens. I was flying with an experienced radio operator who was to expose me to the real world of airborne radio operation and check me out.

Approaching southern France, the Paris controller handed us off to Marseille and I listened as the trainer made contact in Morse code.

Marseille's call sign was FNM. He answered on the fourth call. He was using an automatic telegraph key, known as a "bug," and transmitted faster than I could read. The trainer sent our position report and the estimated time of arrival over Marseille using the international system of "Q" signals, which meant it wasn't necessary for the communicating parties to speak the same language. For three years, I carried an inch-thick book of Q signals everywhere until it was in tatters.

RICHARD THOMSON



Wow, I thought as I listened to the traffic. *This is real radio operating.* Then the trainer told me he wanted me to make the next transmission to Marseille. Although I acted in what I thought was a confident, devil-may-care manner as I changed seats with him, I knew I would blank out, forget the code, and end up as an Air Policeman, forced to wear one of those funny white hats.

My trainer told me to write out what I was supposed to send. Then I listened to Marseille work other aircraft and tried to make sense of it. I got a word or a Q signal here and there, but not enough to read his work on that bug. More thoughts of grounding: They would send me to the motorpool to do oil changes.

I needed a cigarette but before I could light one, the trainer tapped my arm and pointed to the big radio compass needle, which indicated that we were passing Marseille. I was out of time. With the unlit cigarette dangling from my mouth, I hunched over the key.

I guess all those months of code school had had some impact, because I found my fingers tapping out what I wanted to send. Marseille replied, telling me to go ahead, and I even understood him. The signal for "Go ahead" is the single letter "K," which isn't a big deal, but at the time it seemed like great progress. I sent the position report, remembering to note the time for the log, and ended with "BT" (end transmission).

By God, I did it! I thought. I was so excited I forgot to listen to the reply and had to ask him to repeat it. He did, and still I couldn't read it. I was about to send another repeat request when the trainer pushed my hand away, sent "R" (roger, for "understand") and then the letters "TU" (thank you). After a short pause, Marseille answered with two dits on his key—a radio operator's "you're welcome."

Not sure of what I should do next, I just sat there. The engineer, sitting on the floor because there was nowhere else for him to sit with an extra crew member on the flight deck, lit my cigarette. He and the trainer had their poker faces on, but then the smiles came as they shook my hand and pounded me on the back. I grinned with relief.

I stayed in the radio chair and sent the next report over the FIR boundary, slower this time, and copied Marseille's reply without having to ask him to repeat. Following the trainer's example, I sent him a TU. After a long pause, Marseille replied with two dits.

Much later, I found that that Mr. Marseille reserved those two dits for a select few. In my case, knowing I was a student, I'm sure he thought about it before deciding to throw me a morsel. I guess he thought I was barely smart enough to develop into a real radio operator.

Several weeks later I was a newly checked-out operator, new wings on my cap, flying through the Marseille FIR without a trainer. Mr. Marseille was on duty. At the end of my last position report, I sent him a TU, and after a short pause, he sent back two dits. As time went by and I became more proficient, he came to know my "fist," a radio operator's unique style, and I his. I could communicate on a level acceptable to him, and as my speed went up I seldom had to ask him to repeat. I began to wonder about him—who he was and how he got so good. I could hear him working other traffic, mostly civil aircraft, and marveled at his speed. When he was on the air he was in absolute command. He was a stickler for proper radio procedure and etiquette and God help the operator who wasn't ready when he called. When he got angry his speed would go up and up until nobody could read him. That, of course, made him even angrier and he would just go off the air for about twenty minutes and wouldn't answer anybody.

He got mad at me a time or two, but mostly we got along. He recognized me when I flew through his domain. There was a quality of "welcome" in his reply to my callup that wasn't there for just anybody. He would occasionally ask me to relay to other aircraft he wasn't able to reach, and I flattered myself that he was asking me because I had become such a polished radio operator. More likely he knew our aircraft had the most powerful transmitter in the air.

After I had been flying about a year, I felt my skill and proficiency were at their peak. I was a Morse code whiz and could work Marseille like nobody's business. But I was hampered by the old manual Morse key that was screwed down to the radio desk.

What I needed, considering my fantastic proficiency level, was some way to improve my speed. Man, if I had a bug—an automatic telegraph key like Marseille's—I'd be right up there. I wrote to my father in Santa Fe, whose boss was a ham radio operator. They found me a bug, and it soon arrived.

The guys in radio maintenance were kind enough to make me an oscillator with a little speaker so I could practice with my new toy. A standard key is pressed down against a spring, and the length of time one holds it down determines whether the signal is a dot or a dash. One has to have good rhythm to make the hand do what the brain is thinking. An automatic key has a long rod with a weight that bounces against a spring, sending the dots very fast. Pressed the opposite way against a regular spring, it sends dashes. One doesn't pound up and down on a bug—one caresses it, from side to side. A really fast operator can get that weight bouncing so fast it chirps like a cricket—hence the name "bug."

I practiced diligently and my speed began to climb. I was ready, I thought, for Mr. Marseille.

During preflight for a mission to Athens, I disconnected the leads from the standard key and hooked up my bug. When we reached the Paris-Marseille FIR boundary, I listened to Marseille for several minutes before Paris handed us off, took a deep breath, and blasted off with my new bug: "Marseille, this is Air Force 38145, over." He ignored me. A short time later I called again. Could he read my fist on the bug? After another pause, he told me to go ahead.

I sent our position report as fast as I could make that bug go, probably about 45 words per minute, and ended with a BT (end transmission) and a K (go ahead). I could have been Artur Rubinstein ending a Chopin concerto, waiting for the applause.

The elation was fleeting. Marseille came blasting back on his bug at what must have been a hundred words a minute. I couldn't copy.

I asked him to repeat, along with the signal to send slower. He slowed to about 75 words a minute. I still didn't get it all. Once more I asked for a repeat and a slowdown. This time he replied very, very slowly, maybe 5 words a minute. Humiliated, I copied his acknowledgment and his instructions to report passing Marseille and to maintain altitude.

I was about to send my usual R (copied) and my usual TU when he sent, in plain English, "Go back to the radio

school, 38145, Marseille out."

I had violated the first rule of Morse/carrier wave transmission: never send faster than you can receive because that is the speed at which the reply will come. Mr. Marseille had put me very securely in my place. We both knew who was the amateur and who was the professional.

Crushed, I disconnected my bug and used the standard key for the next call over Marseille. He answered in the normal way, slowing his speed to match mine. At the end I sent TU, and after what seemed like an overly long pause, he replied with dit-dit. He and I never referred to the incident again, but I think a kind of mutual respect came out of it. He knew it was me who had made a try at him. Who knows? Maybe he was flattered.

As a check operator, when I took a new student through Marseille FIR, I would make the first call and then turn it over to the student. I think Mr. Marseille, who made it quite clear he didn't suffer inept radio operators, was just a little easier on my students because he knew they were with me. But no dit-dits for them. On departing the FIR, I would take the key and send FNM TU and back would come my two dits.

My last flight through Marseille was in the spring of 1959. I was flying alone on return from Tripoli. I knew it would be my last trip this way. I listened ahead, hoping Mr. Marseille would be on duty. But it was someone else.

Crossing the boundary, I opened my key and called Marseille. The operator replied with a go-ahead and I sent him our track, altitude, and estimated time of arrival over Marseille. There was a short pause. I was about to ask if he copied when I recognized Mr. Marseille's fist as he told me he copied and to report over the beacon. Happily, I sent him a TU and got my two dits.

I was elated. I listened as he scolded some other aircraft for being late on his call and missing his arrival time. Twice he asked me to relay. Did he do it to make me feel good?

Eventually the time came for the last call leaving the Marseille FIR. I sent the report and he acknowledged, ending with "Marseille out."

I knew it was a violation of radio procedure, but risking his wrath, I sent "M. [Monsieur] Marseille TU for working my flight. Leaving for USA 6/29, will miss you, go ahead." Normally, he would have given me hell for cluttering the air with unnecessary information, but he replied, "M. Air Force, good luck from M. Marseille." I sent "Goodbye TU." He replied with two evenly spaced dits, then in plain language: "au revoir."

—Charles L. Lunsford

WAR GAMES

JAN ADKINS

Recently I saw in a Los Angeles store window a banner that at first glance did not bode well for Sino-American relations. In large black letters, it read "Chinese Liquidation." I knew the building was occupied by a merchant specializing in Asian and Mideastern goods, so I was fairly certain the sign wasn't a call to arms. However, it reminded me of a report I ran across more than 35 years ago when I was working as a technical writer for North American Aviation in El Segundo, California.

In the mid-1950s, North American's publications department was a pleasant place to work, considering that we writers and artists—technical illustrators, mostly—were in what we irreverently called the death-and-destruction business.

My assignment was to prepare the armament section of the maintenance manual for the F-100 Super Sabre, the world's first operational fighter capable of supersonic speeds in level flight. My connection with armament was somewhat remote, since I had no interest in or experience with guns. I did have an aircraft maintenance background though, having gotten an aircraft engine mechanic's license and served as a B-17 flight engineer and crew chief in World War II.

Preparation of technical manuals for military aircraft didn't leave much room for imagination. The text had to be straightforward and full of facts and figures, step-by-step instructions, and lots of warnings and cautionary notes, with a numbing lack of verbs and adjectives.

I took pride in writing clearly and accurately. I remembered B-17 manuals that, for example, would list the half-dozen steps required to remove an oil tank but omit mention of things like the immovable nuts, bolts, and other fasteners that cold, heat, vibration, and a few hundred hours of flying time had put between the reader and steps one through six.

Occasionally a visit to North American's technical library was required. It didn't offer a comfortable reading room, but you could check out books, reports, and other relevant or possibly interesting documents, depending on your security clearance. The library also circulated a list of new publications, and it was on one of those weekly lists that I first read about "Presented Areas of Average Prone Chinese Infantrymen."

I had to see that document. Fortunately, the publication was not classified beyond my clearance level, so I was able to check out a copy.

It was a technical report, the outcome of a Department of Defense study by Johns Hopkins University. I only vaguely recall the introduction, which I believe made up most of the text. But I'll never forget the illustrations.

On each of the hundred or so pages was a high-quality black-and-white line drawing of an Asian soldier lying on his stomach and aiming a rifle. Each drawing was of the same impassive rifleman with full infantry pack. The only detectable difference was that each illustration depicted the subject from a slightly different angle of elevation and azimuth.

The report was obviously designed to show pilots and gunners the horizontal and vertical angles from which one could get the largest target area of a prone soldier. That the drawings were of a Chinese infantryman was not a random choice. The Korean war had recently ended, but the report had been commissioned months or even years earlier. The Chinese, of course, were allies of the North Koreans.

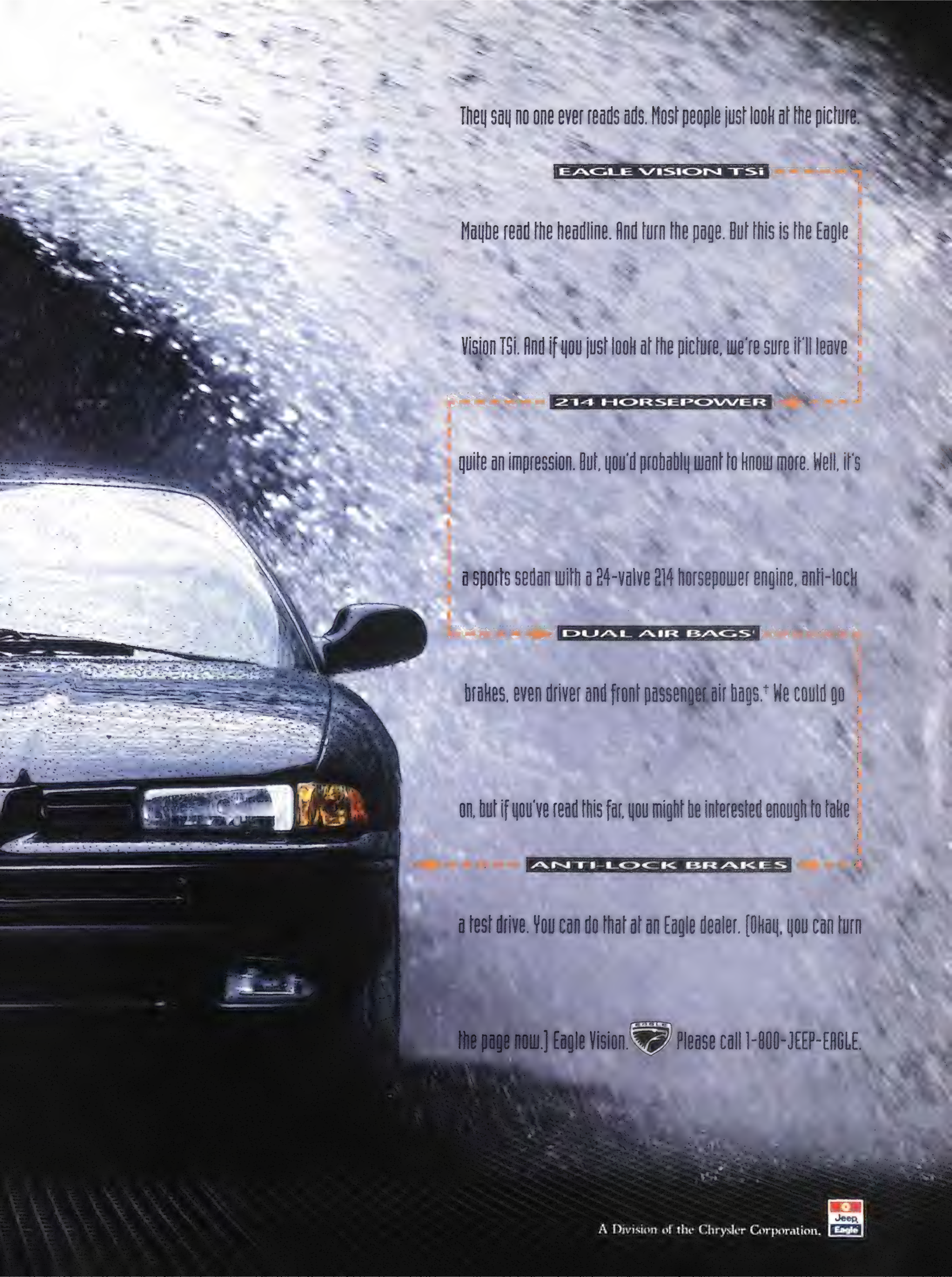
The report caused quite a stir in the publications department. However, there weren't many ardent pacifists working on technical manuals for warplanes, so most of us accepted it as an unusual but not surprising example of military documentation.

Eventually we decided that the Chinese were undoubtedly working up a similar study entitled "Presented Areas of Average Seated American Technical Writers." This was in part an attempt to raise our status, since we were only minor components in the booming military-industrial complex.

I haven't been directly involved in any military activity since then, but I assume similar reports are still being generated. I'm sure they're much more sophisticated and a lot more frightening. With relations between China and the United States fairly stable and with the emphasis on economic partnership and the huge market China offers for American goods and services, I'd bet a study of Average Chinese Snack Food Consumers or Average Chinese Television Viewers would be a lot more useful than drawings of an enemy's prone infantrymen aiming shoulder-mounted missile launchers. And it wouldn't have to come out of the defense budget.

—Ben Warner

†Always wear your seat belt.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"DID HE SAY FIVE

PHOTOGRAPHS COURTESY NASM

Fifty years ago this June, the Martin Marauder kept a crucial, low-level appointment at Utah Beach.

by Daniel Ford

Painting by William S. Phillips
Illustration by John Batchelor

The details have dimmed with time, so it is impossible to know what altitude the Marauder crews were told to fly over Utah Beach on the northern coast of France. Cornelius Ryan of the London *Daily Telegraph* was sitting in the Nissen hut where the officers of the 386th Bomb Group were briefed. "You may have to bomb as high as 12,000 feet or lower than 1,000 feet," he quoted the group commander as saying. "The cloud height will determine this."

"A low whistle penetrated the silence in the room," Ryan's account went on. "These men knew that the attack might be suicidal if they bombed below 1,000 feet."

The enlisted men got a separate and no doubt cursory briefing. Sergeant Roger Lovelace, top-turret gunner in one of the group's Marauders, believed that the altitude he heard was hundreds of feet, not thousands. "We were to bomb individually from 500 feet," he recalled in an oral history account from the Eisenhower Center at the University of New Orleans. "*Did he say 500 feet?* Boy, that shook us some."

Captain James Wilson was a flight leader in the 386th. When I talked to him last winter, at the Vermont homestead where he retired in the 1980s, he shook his head at the notion that the Marauders were asked to fly so low. "No," he said. Then he added, as cocksure as the young pilot of half a century ago: "But we'd have gone to 500. Oh yes! We'd have gone to 500 if we had to."

In fact, the B-26 Marauder had been built to fly just the sort of mission it was handed on D-Day. In 1939 Peyton Magruder of the Glenn L. Martin Company in Baltimore, Maryland, sketched a medium bomber that the U.S. Army could use to destroy bridges, rail depots, and ships. It suggested a flying torpedo: slender fuselage, clear plastic nose, tail drawn to a point. The wings were short and set high on the fuselage, and each had a Pratt & Whitney radial engine slung

On the morning of June 6, 1944, eight B-26 Marauder groups provided air support for the Allied invasion of the northern coast of France.

HUNDRED FEET?"

U.S. ARMY CENTER OF MILITARY HISTORY

The Germans had expected the Allies to invade at Calais, not Normandy (opposite). Thanks in part to the B-26 attacks, the landing forces at Utah Beach on D-Day suffered only 12 casualties (above).

beneath it in a streamlined nacelle. The vertical stabilizer was huge. Altogether, the B-26 was as fearsome-looking as it was beautiful, and the Army, gambling that the airplane could be taken into service without testing or modification, ordered 201 straight off the drawing board for low altitude missions.

In November 1940 the Martin plant in Baltimore delivered to the Army its first B-26, which an obliging American press described as "Martin's Miracle...the fastest bomber in the world" and as "maneuverable as a pursuit" or fighter plane. By December 1941, when Japan attacked U.S. forces on Hawaii, Wake Island, and the Philippines, a second factory was turning out Marauders in Omaha, Nebraska. It was easier to build airplanes than find crews to fly them, however, and only the 22nd Bomb Group was operational. With 57 airplanes, the 22nd flew to Muroc, California, to protect the West Coast from Japanese submarines.

That winter, Jim Wilson was managing his grandfather's farm, on the same amazingly beautiful hillside where I met him last winter. At 74, Wilson resembles the actor Andy Griffith: silver-haired, big-featured, blue-eyed, and handsome. At 23, when he earned silver wings and gold bars, he must have been the very devil of a U.S. Army airman. He was sent to MacDill Field in Tampa, Florida, as part of the nascent 386th Bomb Group.

By then, Martin's Miracle had become known as the Widow Maker or (since it had no visible means of support) the Baltimore Whore. Airmen jested that the B-26 needed all of Texas to take off and came in to land like a cold flatiron. The problem was the ratio of the Marauder's weight to the area of its small wings, which meant that the airplane required a relatively high airspeed for both takeoffs and landings. The new hydraulics were also trouble-prone, as were the huge four-blade, variable-pitch Curtiss propellers. In one 30-day period the lads at MacDill crashed 15 Marauders, and its overall accident record prompted the Army to consider terminating B-26 production and using another aircraft.

Meanwhile, the Marauder was undergoing a baptism by fire in the Pacific. Having departed California for Townsville in northern Australia, the 22nd Bomb Group attacked Japanese shipping and supply depots at Rabaul from medium altitudes—8,000 or 10,000 feet—in effect serving as a heavy bomber group because the real thing wasn't available. Only four airplanes were lost on those successful, plodding forays in the spring of 1942.

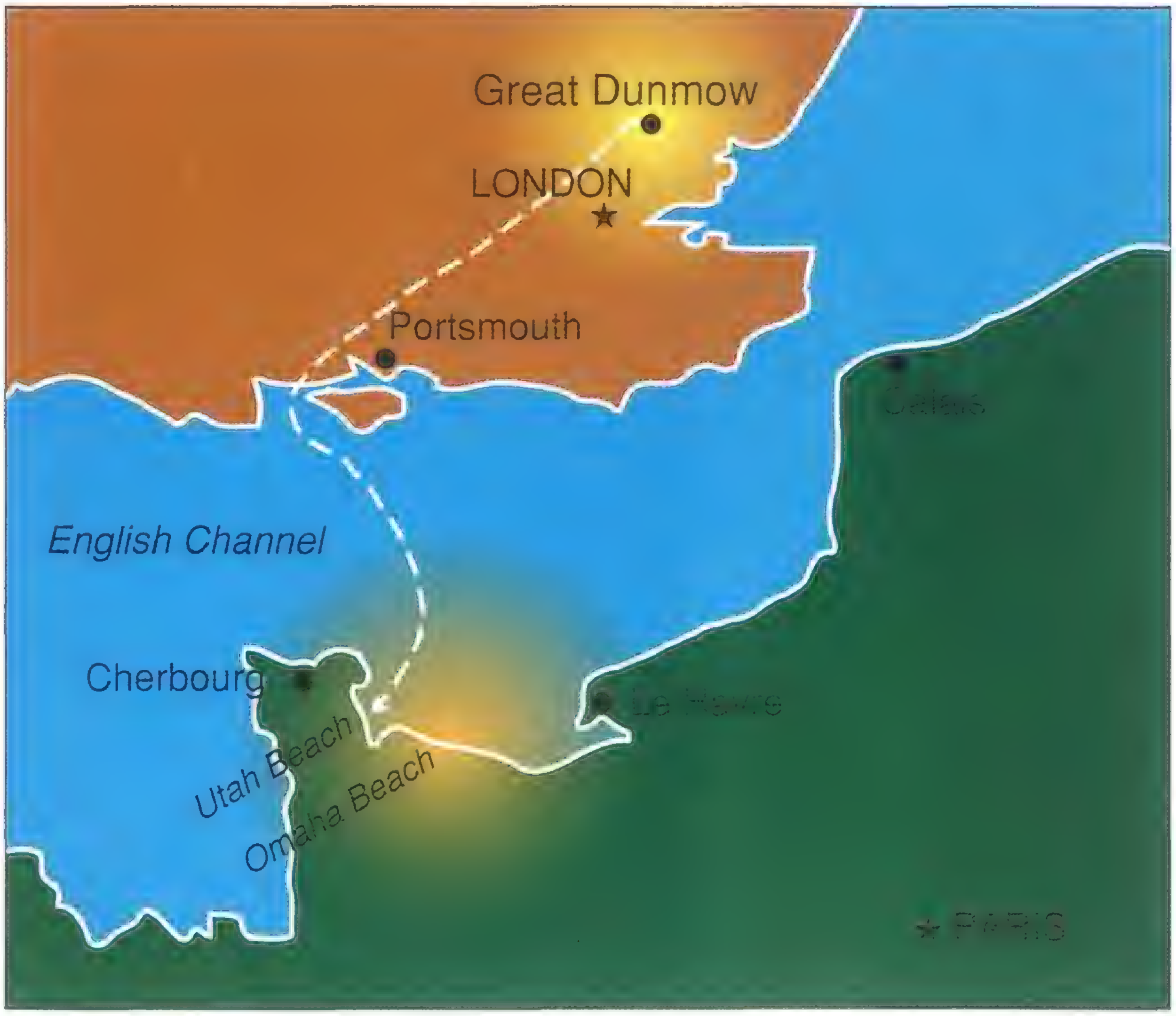
In June, however, at the pivotal Battle of Midway, the B-26 was employed at low altitude. Four Marauders jury-rigged with Navy torpedoes went in at "mast-top level" against the Japanese fleet. Carrier-based Zero fighters shot down two, but the survivors managed to make it back to Midway, where it was discovered that one B-26 had absorbed 500 hits from bullets and shrapnel.

As so often happens in war, all the wrong lessons were drawn from these events. The Marauder was phased out of the southwest Pacific in favor of the North American B-25 Mitchell, which was slower and less durable but also cheaper to build, easier to fly, and better suited to the rough-surfaced airfields typical in that theater. The Army, meanwhile, asked the Martin Company to endow the B-26 with enough forward-firing machine guns that it could duel with an enemy fighter or anti-aircraft battery on equal terms.

"We got to Tampa in July of 1942," Jim Wilson recalls. "I heard afterward that [the Marauder] was a very difficult plane to fly, but none of us knew it. We were young and ignorant and didn't know anything." If its stubby wings obliged Wilson to land the Marauder at 130 mph, why that was okay with him: "That took a lot of the judgment out of it," he explains. "You could come right in under a little power and chop the throttle and you were on the runway." He loved every minute of it. "When we first checked out in them," Wilson says, "we'd go up and play in those big cumulus clouds that build up over Florida every summer afternoon, pretending we were fighters. It was great."

Yes, you could almost pretend that the Marauder was a fighter. "Medium bomber" might suggest the dimensions of a Boeing 737, but a B-26 cockpit had the elbow room of a Honda Civic, with fewer creature comforts, and the instrumentation was less sophisticated than what is found in a light airplane today. (It did have armor-plated seats, and containers of cotton so the crewmen could plug their ears in combat.) The copilot had a yoke and pedals but no instruments of his own. The bombardier crouched ahead of the cockpit in a goldfish bowl so small that he couldn't wear a parachute and his knee brushed the Plexiglas nose when he peered into his bombsight.

Behind the cockpit were the navigation station and radio panel. The bombardier usually doubled as navigator, com-



muting from one task to the other by crawling over the co-pilot, and the radio was operated by the top-turret gunner, who crawled through two bulkheads and the bomb bays in order to reach his panel. A six-footer could easily brush the ceiling with his helmet while standing and brace himself against both walls with his outspread hands. Everywhere there were rivets, cables, tubes, valves, toggles, and hand-lettered signs, suggesting a small-town machine shop more than the electronics center of a World War II aircraft.

In the middle of the fuselage was the bomb bay and its payload: two one-ton bombs or perhaps a score of 250-pounders. Behind the bomb bay were three enlisted gunners, who handled the top-turret, waist, and tail positions. Like the bombardier's compartment, the turrets were so cramped that the gunners seldom wore parachutes, though in combat some of them armored their bottoms with flak vests and scraps of steel, so many layers sometimes that the airplane's center of gravity shifted aft.

In the winter of 1942-43 the 386th moved from Tampa to Lake Charles, Louisiana, where Colonel Lester Maitland reminded his boys that their job was low-level attack—he didn't want to see them higher than 500 feet. "So we all had a ball," says Jim Wilson. "We'd be dragging our wings in the marsh grass and all that sort of thing. Pure joy!"

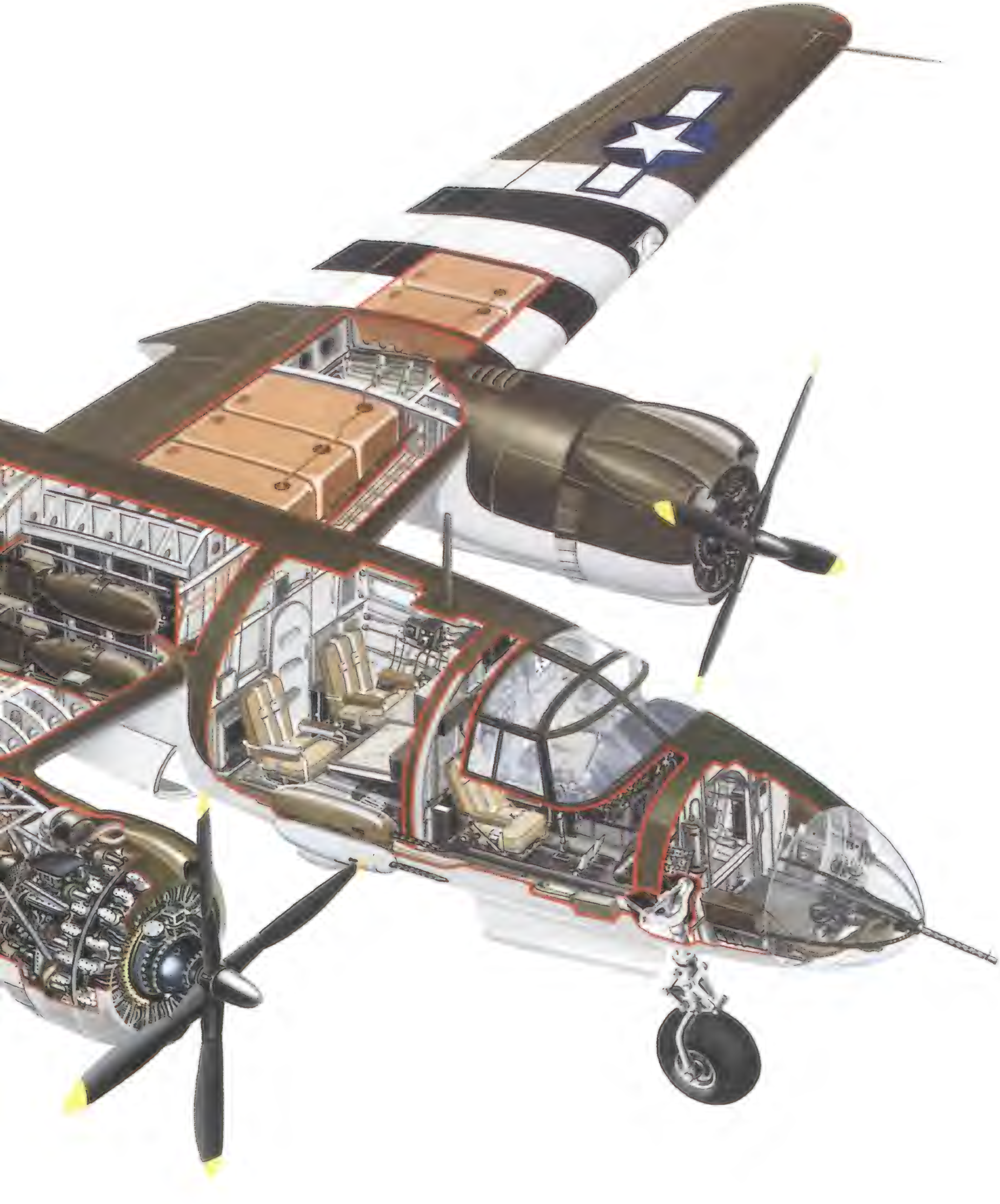
In May the 386th was outfitted with a Marauder variant that had more and larger machine guns, including four fixed guns mounted outside the fuselage—the Army's answer to the debacle at the Battle of Midway. The aircrews set out for Britain by way of Maine, Labrador, Greenland, and Iceland, with a rubber tank in the bomb bay to supplement their fuel supply. "We flew the Atlantic—all us young birdmen," says Wilson. "Remember, we were just off the farm, with a couple hundred hours, and we were ready to go overseas.... I was 24, the oldest [in the squadron] except for the commander and a couple other guys." The ground crews sailed from Hoboken, New Jersey, on the *Queen Elizabeth*, a luxury liner turned troopship that was so cramped the men had to take turns on the five-high bunks, sleeping on mattresses one night and a steel deck the next.

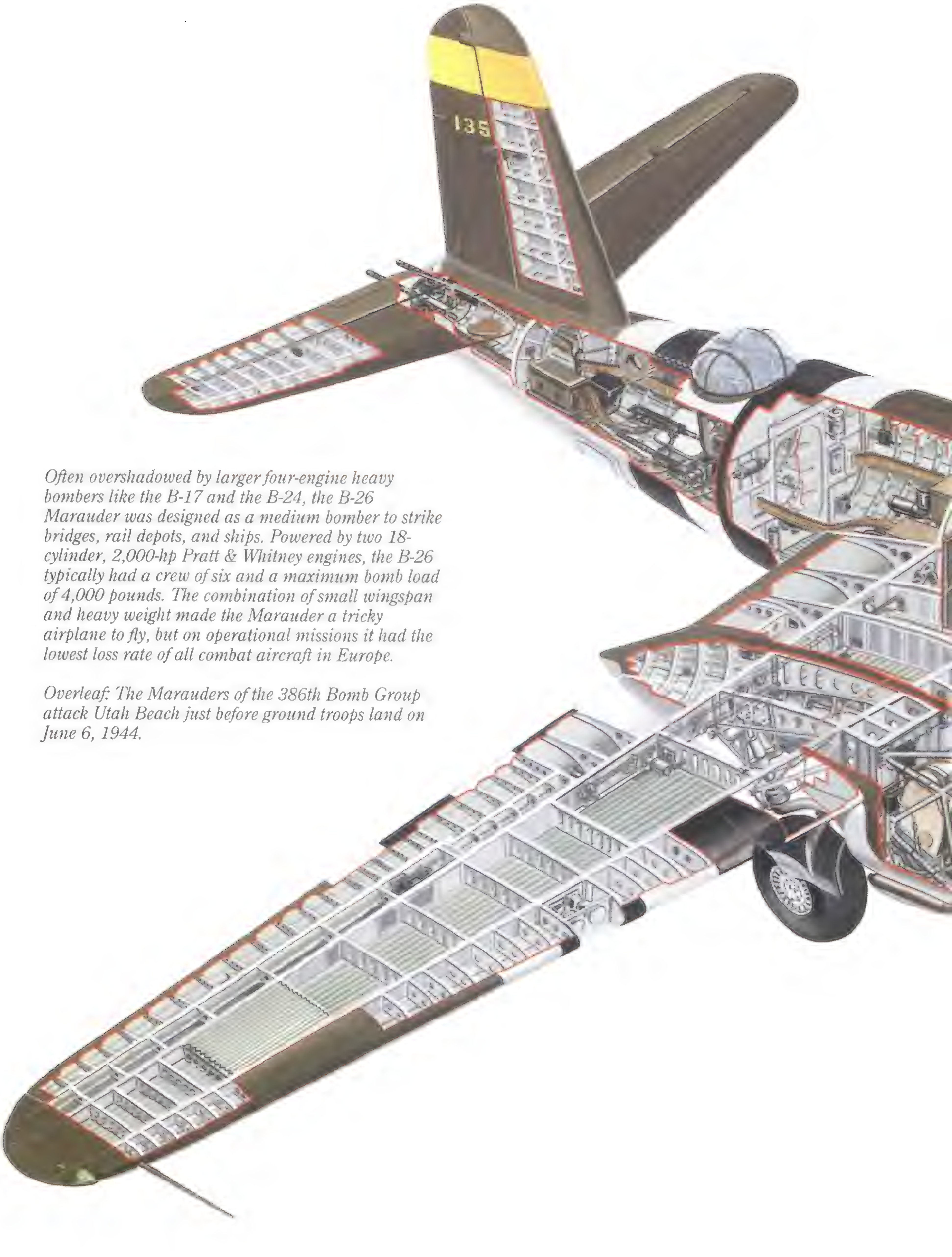
The 386th found a home at Colchester and later at Great Dunmow, some 50 miles northeast of London and 75 miles northwest of Calais in German-occupied France. The men slept in a Nissen hut, essentially a steel culvert cut in half lengthwise with the ends bricked up. An identical hut served as their mess hall, and another as a briefing room.

Their first briefing concerned the 322nd Bomb Group, which had reached Britain ahead of them. On May 17 a squadron from the 322nd set out to destroy a generating plant in Ijmuiden, Holland. Making landfall south of the target, the Marauders roared across dikes, windmills, and German anti-aircraft guns at 250 feet. The lead pilot lost a duel with a 20-millimeter Flak 38 and spun into the ground. Two Marauders collided after one was crippled by flak, and two more were shot down over Haarlem. The survivors were caught by German fighters over the English Channel, and they too were shot down. Ten of the mission's 11 airplanes were lost and 50 crewmen were killed or captured, including Colonel Robert Stillman, the group commander.

A committee headed by Senator Harry Truman investigated the B-26 program, and in a wonderful piece of bafflegab concluded that "the plane is unsafe when operated by any pilots except those specifically trained for its operation." Since six B-26 Marauder groups were already in Britain or scheduled to arrive, the end result was to take the Marauder out of combat for a few months until the Army found a safer job for it.

The four fixed machine guns recently mounted outside the fuselage came off, the pilots practiced flak-dodging tactics, and the bombardiers were given Norden M-7 bombsights, the same sophisticated aiming device used by high-flying heavy bombers over Germany. Henceforth they would bomb from 12,000 feet—as high as the Marauder could fly without a new oxygen system—which was the same altitude the Marauder crews had moved up to in North Africa (the 319th Bomb Group had lost so many airplanes there that it had been refitted with the Norden bombsight and ordered to stay above 10,000 feet). The British-based Marauders were soon reassigned targets in France, Belgium, and Holland, with Royal Air Force Spitfires to protect them out and back. Flying at 12,000 feet—high enough to dodge the worst of the flak, low enough to enable reasonable accuracy—they bombed submarine pens, bridges, railroad yards, factories, coastal batteries, and the launch sites of the world's first jet surface-to-surface missile, the German V-1 flying bomb. On its new mission, losses were under one percent, compared





Often overshadowed by larger four-engine heavy bombers like the B-17 and the B-24, the B-26 Marauder was designed as a medium bomber to strike bridges, rail depots, and ships. Powered by two 18-cylinder, 2,000-hp Pratt & Whitney engines, the B-26 typically had a crew of six and a maximum bomb load of 4,000 pounds. The combination of small wingspan and heavy weight made the Marauder a tricky airplane to fly, but on operational missions it had the lowest loss rate of all combat aircraft in Europe.

Overleaf: The Marauders of the 386th Bomb Group attack Utah Beach just before ground troops land on June 6, 1944.

to the five percent attrition suffered by the heavy bombers. "I came back from Paris once with one engine shot out," says Wilson, "and when we got down we found that a cylinder had been shot out [on the other], so we got all the way back from Paris on one crippled engine. It was an incredible airplane."

The B-26 crews began to anticipate their promised week of leave after 25 missions and a trip home if they survived 50. "I remember the first guy in our squadron who reached 50," says Wilson. "He came in, buzzing the field, shooting off flares and one thing or another.... No deal! D-Day was in the minds of the powers that be, so we just stayed."

All aircraft participating in the D-Day invasion were painted with black and white stripes during the night of June 5-6. Allied gunners would consider any aircraft not wearing the invasion stripes to be an enemy.

The challenge of D-Day was to put a mass of men and machines on a narrow stretch of coast, pitting them against an enemy with all the time in the world to dig in. Five beaches were selected. From east to west, they were code-named Sword (assigned to the British 3rd Division), Juno (Canadian 3rd), Gold (British 50th), Omaha (U.S. 1st and 29th), and Utah (U.S. 4th). Parachute and glider troops would secure the eastern and western flanks, like bookends on a bloody shelf that extended 50 miles.

D-Day now seems fixed in amber as the sixth day of June, but in 1944 the term still had its original meaning—a benchmark on the calendar from which to plan any military operation: bomb this bridge on D minus one, advance to that river on D plus two. The same was true of H-Hour, which at Utah Beach was set for 6:30 a.m. To wring the most out of every day, Britain operated on "double summer time," two hours ahead of Greenwich, requiring the aircrews to go to bed at dusk and awaken to black night.

Not only black, as it happened, but wet—"weather a duck wouldn't fly in," remembered the 386th squadron leader, Colonel Sherman Beatty, in a speech after the war. The crews were rousted from their bunks at 2 a.m. to stumble through the rain and eat what passed for breakfast. "I nibbled some toast and drank some black coffee and drank some sour grapefruit juice," said Sergeant Roger Lovelace, the top-turret gunner, in the Eisenhower Center oral history. "I promptly threw that up along the path on the way to the briefing room."

"We were briefed that morning about three o'clock," Jim Wilson says. "First of course the group commander told us what was happening, that the paratroopers had already landed. This was the first we'd heard about it. Everyone cheered. Oh man!"

At the target, Colonel Joseph Kelly explained, daybreak would come at 5:45 a.m.—H minus 45. The first Marauder group, the 344th, was to cross the shore at H minus 25, blasting German strongholds in concert with the Navy guns, and the last group would finish at H minus 5. That group would be the 386th—a great honor, as the commander pointed out. Bomb early, and the Germans would have time to raise their heads; bomb late, and the U.S. 4th Division would be hit by American bombs. Their window was two minutes: 6:23 to 6:25 a.m.

Then the briefing officer opened a green curtain to reveal a map of the English Channel, with a colored ribbon running to the shore of northern France—not to nearby Calais, as they and the Germans had been led to believe, but to Normandy, 200 miles southwest.

"When we got up to our airplanes after the briefing," says Wilson, "all our planes had these invasion stripes painted on them—black and white stripes. That was all done that night. Anything that didn't have those stripes on it [would be] shot down." British workers had stayed on the job on Whitsunday, a religious holiday, to mix 100,000 gallons of water-based paint for the air armada. "When we took off," says Wilson, "it was in the rain and we had maximum effort, which was 54 airplanes, and it was dark, and 54 airplanes ended up in pretty good formation before daylight." (The 9th Air Force history says the count was 53.)

Not every group fared so well. Pilots were taking off at 20-second intervals in what for many was their first night flight, and they were groping into formation with the help of navigation lights, flares, and good-luck charms. "The weather was ghastly—low clouds, drizzle, and fog," said then-Lieutenant Charles Middleton, a bombardier in the 344th. "We missed the main formation and chased the group halfway across the channel," he said in the oral history, "and as the sky brightened we caught up with them and took a position that looked empty."

Eight Marauder groups were airborne—424 airplanes in theory, though some of the bombers were assigned to targets other than Utah Beach. Others aborted on takeoff, two collided near London, a third exploded in midair, and a fourth ditched in the channel. Others went astray and either turned back, tacked onto another formation, or continued as a "box" of one. Perhaps 290 Marauders actually reached Utah Beach.

"When we flew over [the fleet]," Wilson says, "it was the most incredible sight I've ever seen in my life.... We were still flying a very tight formation, so you couldn't keep gazing out, but our gunners were whooping and hollering. Just

After D-Day, the B-26's role in France was far from over, whether it was serving as a model in a flying demonstration given to a French priest and his students (above) or preparing to fly on the more dicey mission of air support during the invasion of southern France in August 1944 (below).

thousands and thousands of ships! What I saw that sticks in my mind was the USS *Tuscaloosa* [delivering a] broadside barrage and seeing the flames leap out from those guns, and that whole cruiser rock back, and a roller going out behind the ship."

In the end, combat is borne by individuals—the members of one aircrew, one rifle company. For the German soldiers dug into the sandy bluff known as La Grand Dune, the shock point would be a stone bunker known as Widerstandsnest 5 that had been built into what amounted to a long sandy seawall between the Bay of Seine and a marsh on the east side of the Cherbourg peninsula. Seventy-five boys and old men under the command of Lieutenant Arthur Jahnke were armed with rifles and an assortment of machine guns, flame-throwers, and self-propelled mines. In addition, their arsenal included a few 50-mm guns from French armored cars, two 75-mm cannon, and one of the much-feared "German 88" anti-aircraft guns.

All through the night of June 5-6, Jahnke and his men were kept awake by the sound of aircraft, explosions, and small-arms fire from what they believed was a diversionary raid. "Surely [the Americans] wouldn't walk smack into a fortress," Jahnke remembered one of his men saying. And the tide was going out, meaning that a dawn invasion force would have to cross 800 yards of wet sand in front of fortified bunkers. No less an authority than Field Marshal Erwin Rommel had assured Jahnke that the attack would come on the high tide, when landing craft could drop their ramps against the barbed wire. (In fact, the Americans wanted a low-tide morning, so that combat engineers could destroy the mines and "dragon's teeth"—steel stakes—dug into the gray sand.)

Then the Marauders came. As German author Paul Karl Schmidt reconstructed the scene in *Invasion—They're Coming!*, a "wave of twin-engined bombers was coming in from the sea in impeccable fly-past formation [from east to west]. 'Going to cross the coast north of us,' Jahnke thought aloud. But he had hardly finished speaking when to his horror the first wave wheeled [south] and, flying down the coast, made straight for the strongpoint."

Jahnke was almost certainly looking at the 344th Bomb Group, which was flying in a formation of three boxes that each contained three stacks of B-26s and totaled 50 airplanes. Every Marauder had two 18-cylinder, 2,000-horsepower Pratt & Whitney engines. Even a single airplane thundered like Niagara Falls, and here were a hundred engines beating out 200,000 horsepower—a noise so stupendous it seemed to emerge from the water and the sand as much as from the air.

"The bomb bays opened," Schmidt's account continued, "and almost at once the bombs came tumbling out, dropping with their curious wobbling motion." An explosion buried Jahnke in sand but he dug himself out. So did most of his men, though their guns were badly hit. The 88-mm cannon fired only one round before it died, though that shell may have brought down the Marauder from the 344th Bomb Group that exploded over Utah Beach.

"Not only did we have heavy and accurate flak," said top-turret gunner Raymond Sanders in the oral history, "but we also had light flak and many machine gun tracers coming up at us from the ground. We could even make out the machine gun nests.... And then I saw the plane that was flying just behind us and to our left go down in flames."

The next formation, the 387th Bomb Group, was even lower. "We kept going down, kept going down," said Al Corry. As lead bombardier, Corry wouldn't let the pilot level out until they were at 1,250 feet and below cloud cover. (A U.S. 9th Air Force summary says that the bombs were dropped from

altitudes of 3,500 to 7,500 feet, and pilot and historian John Moench, who knows as much as anyone about the Marauder, accepts that assessment. Yet Corry must have known what altitude he was bombing from, and other pilots and bombardiers speak of altitudes below 3,500 feet. The truth may be found somewhere between the vivid memories and the official record.) To the Germans, it seemed that the high-winged bombers were skimming the waves. "They're only a few feet above the water," marveled one German soldier. Then the naval bombardment began, and for all practical purposes the German resistance at Utah Beach ended. Jahnke's men were killed, wounded, buried in sand, deafened, or dazed by shock.

Bringing up the rear, the 386th Bomb Group had an easier time of it. "They were more interested in what was coming ashore than [in] us," Jim Wilson says of the Germans. "The landing barges were circling—all those water bugs circling—and as we came over every one of them broke for the beach. It was an incredible, incredible sight. One of the tail gunners said that as we cleared the target area, the barges hit the beach, so it was just like *that*"—he says with a snap of his fingers.

Ten landing craft came ashore in front of Jahnke's stronghold, each containing a platoon from the 2nd Battalion, 8th Infantry Regiment: 300 riflemen.

The Marauders of the 386th now banked to the right and flew north along the Cherbourg peninsula. The crews looked down at a landscape littered with the parachutes and wrecked gliders of the American airborne troops. One crewman remembered a Norman castle; another saw a farmer stoically plowing his field behind a horse; and a third, tracer bullets arcing toward him.

Indeed, Utah Beach had been a snap. Out of some 290 Marauders, only one had been shot down over the beach. They dropped 550 tons of bombs, which, along with the naval bombardment, exploded the German land mines, silenced their cannon, pulverized their dragon's teeth, and created so many foxholes that on D-Day morning the U.S. 4th Division lost only 12 men—less than the number killed in a practice landing in Britain. Wrote an Army historian soon afterward: "The enemy coastal garrisons, apparently demoralized by the preparatory bombardment, showed little fight; some did not fire at all." It was a miracle of warfare, and at least some of the credit goes to the Martin B-26 Marauder, bombing at low level for the first time in more than a year.

Twelve miles east, by contrast, Omaha Beach was a shambles, with 3,000 men drowned, killed, injured, or missing in an assault so confused that the second wave was almost diverted to the British beaches, which would have meant abandoning Utah Beach and the American airborne troops as well. Again, many factors were at work, but some of the blame falls on the heavy bombers. These high-altitude precision machines—1,083 B-17s and B-24s—never saw the defenses they were supposed to destroy. They dropped 2,944 tons of bombs through the clouds, and even the official air force history concedes that the bombs exploded as far as three miles inland, and that only "shorts" actually hit the beach.

After D-Day, the Marauders for the most part returned to their customary altitude of 12,000 feet—medium bombers at medium altitude. The low-level mission once envisioned for them would henceforth be filled by "swing-role" fighters, notably the big, rugged P-47 Thunderbolt. Fighters were cheaper, faster, and more maneuverable, and in the jet age they would be able to carry a bomb load far greater than that of a World War II heavy bomber.

As it turned out, then, the U.S. Army had taken the B-26 into service, and the Glenn L. Martin Company had built 5,157 of them, for a low-level mission that proved feasible for 20 minutes—6:05 to 6:25 a.m., June 6, 1944—over La Grand Dune, which history would know as Utah Beach.

essay

The Survival Equation

Robert L. Crandall, Chairman and President, American Airlines

In recent years, the economics of commercial aviation has become a hot topic. While there are many points of view, there is no disputing the fact that the *sine qua non* of successful competition—in aviation as well as every other business—is to be either the low-cost producer or, at worst, to avoid a significant cost disadvantage. Those who fail the test of competitive costs have little long-term future.

In terms of operating costs, U.S. airlines are now divided into two distinct groups. One includes high-cost carriers—American, Delta, United, and a few others. The other group includes several kinds of low-cost airlines. There are carriers like Continental Airlines and TWA, which were established long before deregulation and once had high costs—particularly labor costs—but have used the bankruptcy process to lower them. The significant deregulation-era carriers, like Southwest Airlines, derive their low costs from simplified service procedures, productive labor contracts, and relatively junior workforces. Finally, several new carriers further reduce costs by acquiring aircraft, facilities, and services in a buyer's market.

American spends $1.5 billion more than Continental to produce the same amount of salable product.

The differences in expenditures between the high- and low-cost groups are immense. American, for example, spends $1.5 billion more than Continental to produce the same amount of salable product. The precise figures aren't overly important, but the magnitude of the discrepancy is.

The high-cost carriers, which need higher fares to achieve profitability, have few attractive options. Raising prices to cover rising costs won't work because the consumer's preference for, and increased access to, low fares has changed the industry irreversibly. Low fares are here to stay and are likely to become more widely available as low-cost carriers continue to spread their wings into new markets.

In recent years, more and more low-cost capacity has appeared. Today, low-cost carriers operate nearly one-third of the industry's capacity, and it seems clear that the number of efficiently produced, low-cost seats will increase. The only question as yet unresolved is how many of today's high-cost carriers will be able to solve their cost problems and survive, and how many will be relegated to history.

At most carriers, specifically the high-cost, old-line carriers, labor is the largest operating cost, accounting for more than a third of operating expenses. In one way or another these carriers must find some way to lower unit labor costs to something approaching parity with their lower-cost competitors. Unfortunately, neither those of us who manage airlines nor those who critique our efforts have come up with a successful way to do so. If labor costs are to change, either per-hour compensation or the work rules that constrain productivity must change dramatically. Understandably, airline people everywhere are reluctant to accept such changes.

The equation is complicated by the fact that at most airlines, strong unions—with agendas that do not include lower unit costs and with leaders who must frequently stand for reelection—are part of the fabric of corporate life. To date, finding mutually acceptable solutions, or even agreeing on the extent and nature of the problem, has been an elusive goal. Nonetheless, if we are to find solutions to the cost problem, they must reflect the shared commitment of management, unions, and employees.

Matters are further complicated for airlines by the environment in which pilots and flight attendants work. For one thing, they have fewer opportunities to interact with other groups of employees, and, as a result, do not have the same sense of common purpose that is created in a fixed workplace populated with the same people day in and day out. These well-paid and highly skilled people also operate almost without

Some once-stalwart old airlines face a painful choice: cut labor costs or die.

supervision and thus have far less contact with management than do other employees. As a consequence, unlike other work groups, they get little exposure to company perspectives and attitudes.

The always-fragile linkage of these groups to their company's management has been further weakened in recent years as airlines, seeking to streamline operations, have steadily reduced the ranks of the supervisory workforce. Today's cockpit and cabin crews, who take great pride in representing their companies and are naturally loyal to them, have far fewer opportunities for dialogue with management representatives than they did in times past. This reduced level of interaction is sometimes interpreted by flight personnel as a lack of interest in their views and a lack of respect for their contributions.

While neither interpretation is correct, perception is often more important than reality, and consequently both pilots and flight attendants have come to rely heavily on the opinions of their union leaders, whom they perceive as the ones most protective of their interests and most knowledgeable about their situation. When union leaders have views and agendas very different from those of corporate management, the result is conflict. In disagreements between such strong institutional groups, it is very difficult for employees to discern what is true and what is false in competing arguments. At American, this phenomenon resulted in a flight attendant strike last year that was truly a tragedy for all involved.

We must find better ways to resolve conflicts and disagreements between companies and unions because in one way or another, every major U.S. carrier must confront the fact that in a savagely competitive, commodity-equivalent retail business, any participant whose costs are materially higher than those of its competitors simply has no long-term future.

Moreover, everyone involved must come to understand that the impact of labor on commercial aviation costs is so overwhelming that the actions—or inaction—of union leaders will, more than any other factor, decide the shape of the industry's future. Since that outcome will determine the fate of all airline workers, bridging the cost gap well enough to ensure the company's long-term success is clearly a responsibility shared by union leaders and airline management.

Those who fail the test of competitive costs have little long-term future.

In due course, the industry will restructure itself so that the labor costs of all airlines will be in line with those of today's lowest-labor-cost carriers. That "due course" will be shorter if unions and management at major carriers are able to work out mutually acceptable ways to reduce costs. Thus, in the years ahead, both the composition of U.S. commercial aviation and the rate at which it restructures itself will depend upon what airline employees, and their unions, are willing to join airline managers in doing, and when they are willing to do it.

Commercial aviation remains one of—if not *the*—most exciting businesses in the world. But if it is to achieve its full potential, those directly involved with today's high-cost airlines—managers, unions, employees, and investors alike—need to press the search for acceptable ways to create the competitive cost structures that are absolutely essential for long-term financial success.

And, because airline management and unions cannot struggle with these issues alone, everyone interested in the long-term health and world leadership of America's airlines needs to help our government, the press, and the public understand the need for sound, carefully thought out, growth-oriented, long-term aviation policies.

These steps will, over time, create a host of opportunities for air carriers, and will vastly expand the economic and travel opportunities of consumers and citizens around the world.

Apollo's Geology Lesson

The rocks and dirt that the astronauts brought back from the moon gave scientists new understanding of an ancient world—but tantalizing questions remain.

by Billy Goodman

In July 1969, a group of scientists waited at NASA's Lunar Receiving Laboratory in Houston, eager to get their first look at rocks brought back from the moon. "The Lunar Receiving Lab was like a medieval monastery waiting for a piece of the true cross," remembers Robin Brett, who was chief of geochemistry at Johnson Space Center. "There was incredible excitement, like something mystical was about to happen."

For months, the scientists who made up the Lunar Sample Preliminary Examination Team had been preparing for the moonrocks. Just as the astronauts had simulated every aspect of their mission, the PET members had practiced theirs. "A lot of the simulation was establishing protocols for staying within the guidelines of the quarantine and still extracting information from the samples," remembers Grant Heiken, a geologist fresh out of grad school at

NASA/JOHNSON (2); MISSION PATCHES COURTESY BOB CRADDOCK

Was the moon hot or cold? Were its craters formed by volcanoes or meteors? The scientists who first examined Apollo 11's specimens hoped to get answers to these basic questions.

the time. Despite the 20-hour days, Heiken recalls, "it was such an exciting time. People would have done damn near anything to look at those rocks."

Apollo 11's lunar material had been sealed inside two aluminum boxes. They were to be opened in a specially constructed vacuum chamber, created to mimic the near-vacuum of the moon's environment and to prevent the escape of any lunar microorganisms (see "The Great Lunar Quarantine," February/March 1994). Jack Warren, a burly ex-roughneck who still works at Johnson, had won the right to open the boxes by drawing the shortest straw. Four PET geologists gathered around the vacuum chamber to provide play-by-play as Warren, his hands inside gloves that protruded through the sides of the vacuum chamber, opened the containers. "I opened the box and saw a lot of dust," Warren says. "I wasn't that impressed, but all the electricity in the air from people wouldn't let you be down."

Geochemist Brett, one of the four scientists who crowded around the viewing ports to watch Warren open the boxes, recalls his first impression: objects that "looked like dirty potatoes." The samples may have appeared unimpressive, but they were about to revolutionize lunar science.

Rocks and Minerals

Although the word "geology" is derived from the Greek for "study of the earth," the science has successfully made the leap to the moon and the other planets. ("Selenology," from the Greek word for "moon," was used for a time to describe the lunar applications of geology.)

With its hot interior, shifting continents, and active atmosphere, Earth has been hell on rocks; everything geologists have to study has been altered or created after Earth formed 4.6 billion years ago. That's why cold mooners hoped that the moon would be a primordial remnant from the beginnings of the solar system, "untroubled by all the geologic indignities that have been inflicted on Earth and other large planets," as Don E. Wilhelms wrote in *To a Rocky Moon.* It wasn't. Moonrocks have proven to be either igneous (formed by the solidification of magma or lava) or metamorphic (altered by great heat and pressure). There are no lunar sedimentary rocks, which require water to form. The material returned by the Apollo astronauts has been classified into four categories: Type A (fine-grain igneous rocks), B (medium-grain igneous rocks), C (breccias—rocks made up of pieces of different rocks fused together) and D (lunar soil, or regolith).

The basic building blocks of rocks are minerals. For instance, lunar anorthosite is a rock that is composed largely of a single mineral, plagioclase. Lunar anorthosites differ from the terrestrial variety in the makeup of the remaining 10 percent of the mineral content.

Apollo 11's scientific value was all the more gratifying since its science had taken a back seat to the political goal of fulfilling President Kennedy's pledge to reach the moon by 1970. Eugene Shoemaker, probably the leading lunar scientist of the time, charitably describes the field geology portion of Apollo 11's mission as "extremely limited in scope." Nonetheless, he jumped at the chance to be field geology principal investigator and admits that "given the time [the astronauts] had, they did a magnificent job." It's as if extraterrestrials had landed in Manhattan and had time to explore only one city block (not the one with the New York Public Library). Indeed, it is remarkable to think that by venturing just a few hundred yards from the lunar module and collecting 58 samples of rocks and soil weighing a total of 47.5 pounds, Neil Armstrong and Buzz Aldrin were able to contribute so much to the understanding of another celestial body.

Before the Apollo missions, the moon might as well have been made of green cheese for all that Earthbound geologists knew about it. The moon was the subject of "hallucinations and fairy tales," as Gerald Wasserburg, a pioneering geochronologist from the California Institute of Technology, puts it. "All we had before Apollo was starlight, feeble examinations of other planets, no adequate samples of any planet that we knew. Discussion of processes were wild speculation, uncontrolled by any facts."

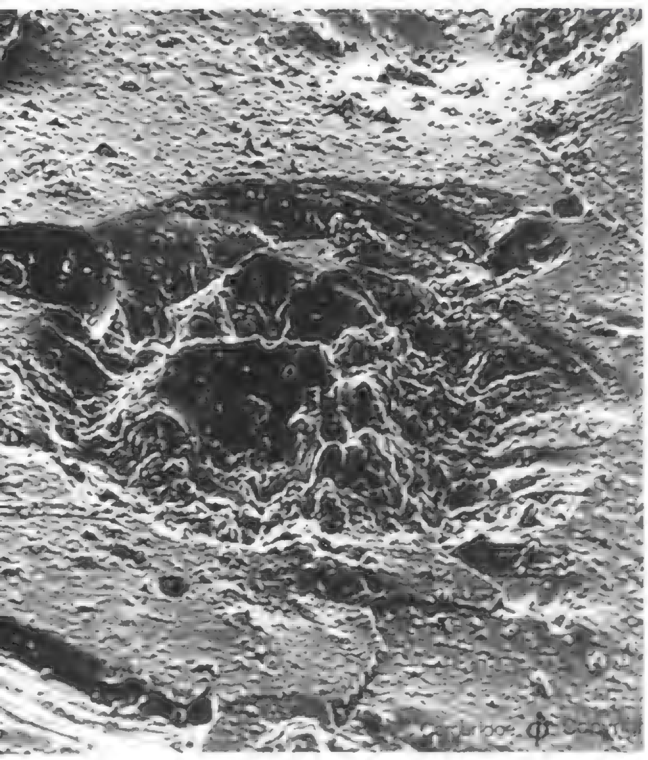
Before Apollo 11, theories about the moon's basic nature were divided into two camps. "Hot mooners" said the moon's surface features were the product of a hot interior. When they looked at craters, they saw volcanoes. They envisioned dark lava filling the maria, the so-called lunar seas (the dark areas easily visible from Earth). "Cold mooners" disagreed. The moon's surface had been cratered by impacts, they said. There were no volcanoes and no lava. The moon was not hot now and never had been.

Chief among the cold mooners was chemist and Nobel laureate Harold Urey. The moon, Urey believed, was not large enough to retain any heat generated by radioactive decay in the interior. He thought the moon formed when Earth did, 4.6 billion years ago, but in a separate part of the solar system and was subsequently captured by Earth. He believed that the moon and the terrestrial planets—Earth, Mercury, Venus, and Mars—formed by cold accretion when debris and planetesimals left over after the formation of the sun clumped together. If he were right, the moon would be an unaltered relic from the birth of the solar system. Legend has it that he once said, "Bring me a piece of the moon and I'll tell you the history of the solar system."

But the rocks Neil Armstrong and Buzz Aldrin picked up at Tranquillity Base proved Urey wrong, putting an end to visions of a cold, primordial moon. The samples showed that the moon was not a solid, undifferentiated chunk of rock; it had evolved. Many of the rocks Apollo 11 brought back were basalts, the sorts that form on Earth when lava flows onto the surface and solidifies. Using radioactive isotope dating techniques, Wasserburg and his Caltech laboratory, the "Lunatic Asylum," determined that some of the basalts had formed 3.65 billion years ago. In other words, the moon was geologically active at least one billion years after its formation. The maria had been formed by outpourings of molten rock from the moon's interior. The basalts and all other samples were utterly dry. The moon

DAVID VANCE

Technician Jack Warren, who opened the Apollo 11 rock boxes, still works at the Johnson Space Center (left). Though the first moonrocks (below) were physically unimpressive, geologists found them fascinating. At left, an electron microscope view shows a pit from a micrometeoroid impact.



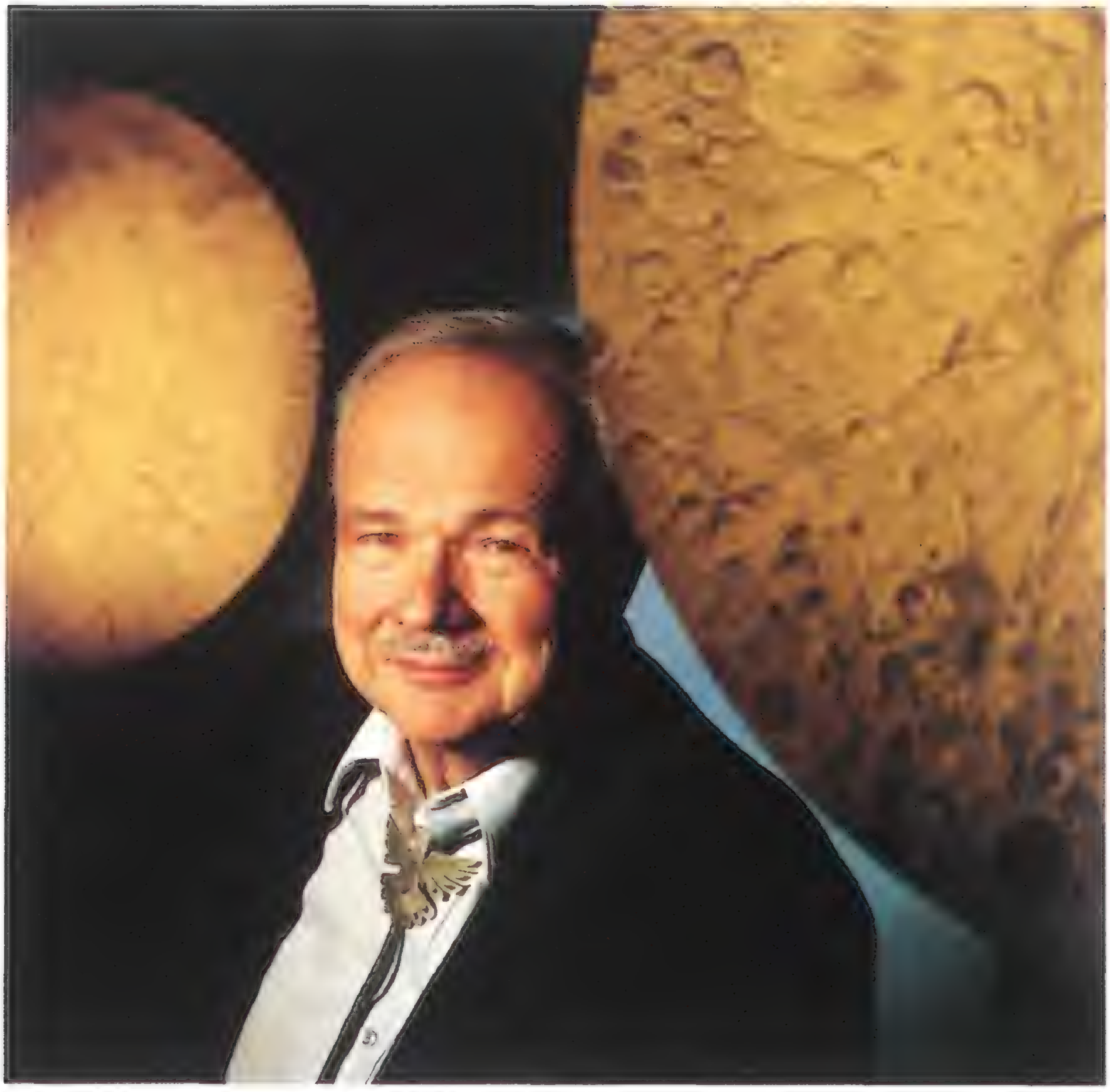
NASA/JOHNSON (2)

had no water, had never had water, and was depleted in other volatile elements, including metals such as lead, which are easily vaporized. These results pointed to a violent, high-temperature beginning for the moon. The hot mooners had no cause to gloat, however. The Apollo missions showed unequivocally that the abundant small craters on the maria were made by impacts, as the cold mooners had claimed. The upper surfaces of many rocks even had glass-lined zap pits, evidence of bombardment by micrometeorites the size of the period at the end of this sentence, or even smaller.

Yet even though five more Apollo missions reached the moon's surface, many lunar mysteries remain. For instance, the maria are much more lightly cratered than the highlands, so they must be much younger. Lunar scientists were presented with a puzzle that is not completely solved today: Why was the moon so heavily bombarded in its first billion years? Why has it been relatively quiet since? What are the implications for Earth? And still open to debate is the biggest question of all: where did the moon come from?

In Houston, the PET geologists studied the rocks, one by one, for a month or so, creating a catalogue that scientists around the world could use to request samples for study. The job of distributing the rocks and other samples fell to the Lunar Sample Analysis Planning Team (LSAPT, usually pronounced "less apt"), which granted samples to 142 principal investigators.

One of those was John Wood, a me-



KATHERINE LAMBERT

Eugene Shoemaker didn't go to the moon, but being principal investigator for field geology was the next best thing.

teorite specialist at the Smithsonian Astrophysical Observatory (now the Harvard-Smithsonian Center for Astrophysics) in Massachusetts. "It's impossible to convey how great a proposition it was to an earth scientist to be able to study a whole new planet," he says. Now a highly regarded senior scientist, Wood ranked fairly low on the lunar science pecking order at the time, a status confirmed by the sample he received:

less than a teaspoonful of soil. "Objectively, it was the most dismal, dreary, grungiest stuff you've ever seen. But it was thrilling."

Rocks from the moon—even lunar dirt—were enough, in 1969, to attract an early morning crowd, which Wood did when he brought his sample home, flouting the strict security rules laid down by NASA. "I spread [the soil] on the dining room table for my neighbors to see," he says. "They brought their kids. They had to come early because I was eager to bring it to work and spread it out for my colleagues."

Far from being envious of others' samples, Wood says that his vial of lunar soil was precisely what he had wanted. "I figured we should gear up to study the dirt, since the big names would fight over the big rocks," he says. "I thought there would be little demand for the dirt. I hadn't reckoned on how interesting the dirt would be—it was a treasure trove of interesting rocks."

Wood's dirt sample—technically known as regolith, which is unconsolidated rocky debris and soil—contained fragments from dozens of rocks that had been broken up by meteoritic bombardment of the lunar surface. Large impacts can move rock great distances—"If you start at one place on the moon and wait long enough," says Shoemaker, "you will get pieces from all over the moon," even from the far side. Small meteorites erode the surface and "garden" the regolith, mixing the top layer. Most of Wood's fragments were dark and roughly basaltic, hardly surprising since Apollo 11 had landed on a lava-filled mare. But a few fragments were distinctly different and lighter in color.

In January 1970, Wood and hundreds of other scientists who had received lunar samples convened in Houston for the Apollo 11 Lunar Science Conference. It was not a typical scientific meeting. Wood recalls "a charged atmosphere, with a lot of press, a lot of cameras, a lot of television coverage. It was truly a national event." Wood spoke on the conference's third day and made a bold conjecture: the lighter fragments in his sample had come not from the mare but from the moon's highlands, which are similar in color. The closest highland was also 24 miles from the landing site, so they must have been transported to Tranquillity Base by an impact. The real surprise was Wood's description of the fragments as anorthosite, a lightweight rock that is relatively rare on Earth. Anorthosite "was the last thing anyone expected on the moon," Wood says, not least because its formation in large quantities would involve a large body of dense magma.

He had an even more audacious theory to explain why the highlands, which make up about 85 percent of the moon's surface, should have anorthosite in the first place. First, he hypothesized, the entire surface of the moon had melted, forming a magma ocean. Then anorthosite, composed of lightweight minerals, had crystallized out of the magma and floated as a scum to the surface, where it cooled to form the lunar crust. For the cold mooners, it was like adding insult to injury. Not only had the moon been

hot, Wood was saying, it was once covered with molten rock more than 250 miles deep!

Today, the lunar samples reside at Johnson Space Center in a laboratory and vault built for them in 1979 (to spread the risk, about 14 percent of the 841 pounds of material brought back by the Apollo missions is stored at Brooks Air Force Base in San Antonio). James Gooding, the curator of the lunar collection, says 85 percent of the samples by weight are pristine, meaning they have not left the lab's care. "Some people say we haven't studied them," he says. "We have, but we use the minimum amount necessary." The six Apollo field parties brought 2,196 samples back to Earth. The collection now numbers more than 90,000 subsamples, as the original rocks have been sawed and chipped to provide researchers access to the same sample or to retrieve interesting-looking inclusions.

"This is an active lab, not a museum," Gooding tells me during a tour of the Pristine Sample Laboratory, which lives up to its name in more ways than one. The gray tile floors look like they've never met a speck of dust. The lighting is bright, fluorescent, white. Along the perimeter of the lab stand stainless steel and glass sample cabinets, one for each lunar mission and a few more. "Our job is to keep the samples as moonlike as possible until scientists work with them," Gooding says. He is dressed, like me, head to toe in white, including gloves and a beanie. He is clean-shaven and I begin to regret my beard. Gooding assures me that previous curators had facial hair.

The cleanliness and the precautions are to prevent contamination of the samples, which are stored behind a 14-ton door that meets Bank Protection Act requirements; the vault is designed to remain standing if a tornado destroyed the rest of the building. Every year, as part of a simulation to cover hurricane procedures, workers practice putting

LOU JONES

John Wood (right) found some surprises in the sample of Apollo 11 regolith he studied.

Apollo 15 commander David Scott examines the "Genesis Rock," perhaps part of the moon's original crust.

a watertight door over the vault door.

The sample cabinets are filled with nitrogen gas, a relatively inert atmosphere that protects the lunar material from water and oxygen. Scientists work on the rocks with rubber gloves built into the cabinets' sides. Inside the cabinets, only three materials come in contact with the lunar samples: aluminum, stainless steel, and Teflon. The two metals are allowed, Gooding says, because iron and aluminum are already major constituents of lunar rocks. Teflon is allowed because it is relatively unreactive and would be easily identifiable should any contaminate a sample. My wedding ring, on the other hand, probably contains more gold than is present in the entire 841.6 pounds of samples; it goes into my pocket before we enter the lab.

In an adjacent lab, technician Carol Schwarz painstakingly processes a regolith core from the Apollo 16 mission. She started dissecting the 13-inch-long core in December at the request of Randy Korotev and Larry Haskin, lunar scientists at Washington Universi-

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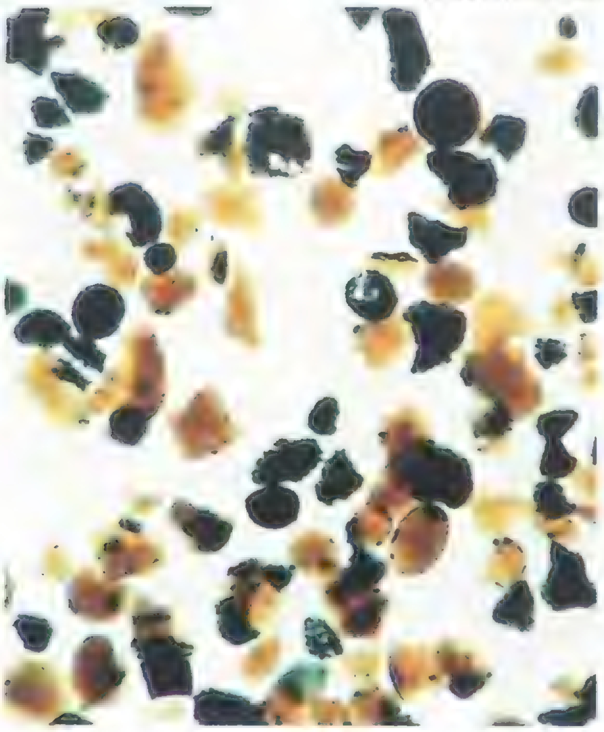


Field Work

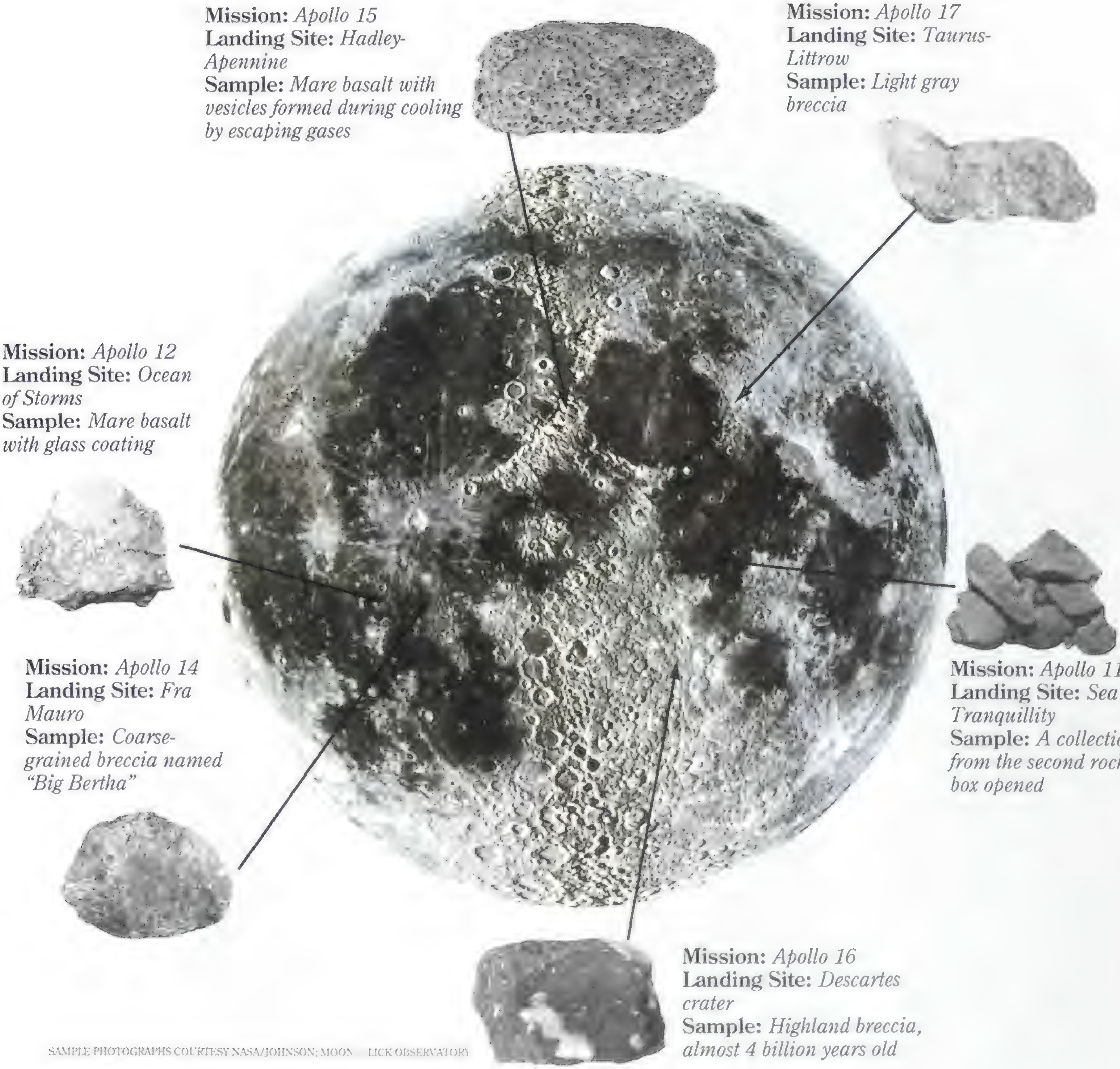
David Scott got a piece of the moon. The Apollo 15 commander, widely regarded by scientists as the most enthusiastic geologist among the astronauts, says he spotted sample number 15415 "sitting on a pedestal [of dirt] waiting to be picked up." He quickly recognized the half-pound white rock as anorthosite—perhaps a piece of the original lunar crust. Sensing the excitement among the geologists at mission control, the press dubbed the find "Genesis Rock" before Apollo 15 splashed down.

Alan Shepard—by all accounts the least interested lunar geologist—got a piece too, an enigmatic seven-pound rock. At first 14310 was thought to be basaltic lava, formed when magma spilled out onto the moon's surface and solidified. The subject of more than 200 scientific papers, 14310 was ultimately identified as an impact melt. It probably formed when a huge meteorite slammed into the lunar surface 3.85 billion years ago. The rock melted by the impact eventually crystallized to form a relatively homogeneous sample.

Apollo 17's Harrison Schmitt (below) was the only true geologist to visit the moon (though geologist Bill Muehlberger says the astronauts were trained so thoroughly they had the equivalent of master's degrees). At Shorty Crater, Schmitt discovered 74220, orange soil composed of tiny glass spheres (left). Schmitt first thought he might be seeing the results of a recent explosive eruption of a small volcano. If that were the case, Shorty Crater would be the first volcanic crater visited on the moon. Shorty Crater was not volcanic, however. Schmitt says the orange glass was from fire fountains, geysers of molten lava that crystallized above the surface, and was protected for the next 3.5 billion years by a lava flow. "When a small impact crater formed, about 20 million years ago, it excavated orange volcanic debris—pyroclastic debris—and put it on the rim of the crater where we discovered it."

These three men and nine others walked on the surface of the moon. With each mission they stayed longer, ventured farther, and did more geological work. Always, however, they were up against what Schmitt refers to as "the relentless pressure of time." A field geologist on Earth can usually go back to an interesting formation the next day, or spend a week if necessary. Not so on a tightly scheduled moon mission. The astronauts' tasks weren't made any easier by their pressure suits, which were as stiff as inflated footballs and difficult to bend in. Many of the astronauts also described how fatigued their hands became working inside the pressurized gloves to get samples. "It was like squeezing a tennis ball" nonstop, says Schmitt, or "changing spark plugs with heavy gloves."

But Schmitt thought it was all worth it. "Being in a truly magnificent set of surroundings is one of those meaningful experiences in life," he says. "We were standing in a valley deeper than the Grand Canyon, looking at brilliantly illuminated mountains all around, with the backdrop of a blacker-than-black sky. A blue marble, over the southwest mountains, added the only color to the scene."



Mission: *Apollo 15*
Landing Site: *Hadley-Apennine*
Sample: *Mare basalt with vesicles formed during cooling by escaping gases*

Mission: *Apollo 17*
Landing Site: *Taurus-Littrow*
Sample: *Light gray breccia*

Mission: *Apollo 12*
Landing Site: *Ocean of Storms*
Sample: *Mare basalt with glass coating*

Mission: *Apollo 14*
Landing Site: *Fra Mauro*
Sample: *Coarse-grained breccia named "Big Bertha"*

Mission: *Apollo 11*
Landing Site: *Sea of Tranquillity*
Sample: *A collection from the second rock box opened*

Mission: *Apollo 16*
Landing Site: *Descartes crater*
Sample: *Highland breccia, almost 4 billion years old*

SAMPLE PHOTOGRAPHS COURTESY NASA/JOHNSON; MOON — LICK OBSERVATORY

ty in St. Louis; she expects to finish by July. Korotev wants to compare it to other Apollo 16 cores he has studied. "I'm trying to understand the site geology and how the regolith forms," he says. "I have been studying Apollo 16 cores since they came back and I still don't understand what is going on there." He says the top soil from all the cores is similar, but at deeper levels differences show up, possibly reflecting conditions of the underlying bedrock.

Almost all the anorthosite from the moon is in regolith grains or in breccias, which are impact rocks composed of angular pieces of other rocks fused together. Until large anorthosite samples are brought back from the lunar highlands, researchers must make do with the fragments of anorthosite they can find, some about as old as the moon itself, to understand the evolution of the lunar crust.

Odette James, a geologist with the U.S. Geological Survey, wants to understand this evolution. She has studied lunar samples since the beginning and admits that "studies are becoming difficult. The exciting first-look stuff has already been done and now we're refining hypotheses." John Wood's magma ocean concept, in which the anorthositic crust floats to the surface, is only a starting point for James' research. "It's a nice idea but not 100 percent proved," she says. "It would be nice to be more sure or to come up with an alternative." For example, one point of contention among geologists is whether there was

DAVID NANCE ©

James Gooding oversees the lunar samples at the Johnson Space Center, where they are rigorously protected from any terrestrial contamination (below).

a moon-wide magma ocean or just localized melts. One way to distinguish between these scenarios, James says, is by carefully studying anorthosite taken from different sites.

She often uses a microscope to see the shapes of mineral grains in sections of anorthosite so thin you can see through them. "You can tell a lot about a rock's history by the mineral grains," she says. You can tell, for example, if a rock crystallized from a melt, and at approximately what depth (deeper-crystallizing rocks have larger crystals). And if it is a melt-produced rock, you can tell something about the composition of the melt. Grain shape, relations among grains, and mineral compositions indicate if the rock has been modified and reheated after formation. James and colleagues have found that anorthosites from different locations on the moon are very similar, consistent with the idea of a moon-wide melt. Yet the samples do show some differences, which haven't been explained.

Neither has the origin of the moon. Before the Apollo missions, the main theoretical contenders were fission, capture, and co-formation. Fission proponents think the moon had been created from material spun out of a rapidly rotating Earth. The theory doesn't explain why the material would have coalesced into a moon, rather than fall back to Earth. Capture advocates, like Harold Urey, believe the moon was snagged gravitationally as it wandered by Earth. That theory runs into difficulty because it requires both a slow-moving moon and one that approaches extremely close to Earth. The theory also runs up against compositional difficulties: If the moon formed elsewhere, why is it so similar to Earth? On the other hand, if the co-formation explanation were correct and both Earth and moon formed together in the same part of the solar system, how can one explain compositional differences?

In the 1980s researchers proposed a fourth explanation for the moon's origin: that it was created when a Mars-size body hit Earth at an oblique angle, sending out a spray of terrestrial material that re-formed into the moon (see "Moon? Boom!" December 1986/January 1987). The impact hypothesis caught on quickly because it fits many observed facts about the moon, including its small or non-existent iron core and its lack of volatiles.

Such a hot, violent beginning also makes Wood's magma ocean more plausible. Together, these two notions have helped make another radical idea more acceptable: that Earth too once had a magma ocean. According to geophysicist David Stevenson of the California

Institute of Technology, that view is now widely held, if not yet included in the standard textbooks.

If any clues remain that can solve the mystery of the moon's origin, they probably will be found on the moon. Geologists are getting a boon from the Clementine mission, a military satellite that orbited the moon for two months in the spring (see Soundings, April/May 1994) and provided the first global coverage for a map of the moon's surface minerals. Clementine's instruments also gathered data for a map of the moon's topography. That information will help geologists tackle a variety of geophysical problems, such as precisely determining the moon's center of mass and relating it to unequal distribution of mare basalts on the surface. The center of mass is slightly offset toward the side of the moon facing the Earth, which is also the side that contains the greatest percentage of maria. Scientists believe the offset may have made it easier for molten rock to reach the surface on the moon's nearside.

Geologists are realists—down to earth, one might say—and are not expecting to return to the lunar surface anytime soon, but some do permit themselves to dream of a return to the moon; a 1990 workshop was even devoted to site selection. Not surprisingly, there seem to be at least as many favorite sites as there are lunar scientists. Those who want to learn more about the moon's early history would like to sample and date impact melts from the oldest basins. Others would like to visit large craters, so they can better understand the impact processes that played a dominant role in the early history of the moon, Earth, and the other terrestrial planets.

At Johnson Space Center, technician Carol Schwarz prepares a core sample for a researcher (right). Twenty-five years earlier, Apollo 11 astronaut Michael Collins (at right) paid a visit to the laboratory.

NASA/JOHNSON

Paul Spudis of the Lunar and Planetary Institute in Houston, one of the scientists involved in the Clementine mission, has been patiently plotting a return to the moon for the past decade. His favorite site is Mare Smythii, on the east edge of the moon as seen from Earth. For geologists, Spudis says, the site has lots of diversity. For astronomers who would like to place a telescope on the moon, it is near the equator—so it could see both northern and southern skies—and the far side, which is shielded from Earth's electromagnetic radiation.

Humans reached the moon to fulfill technological and political challenges. Once there, they had little to do but scientific experiments. The samples they brought back have kept scientists busy for a quarter of a century, and will keep some busy for a good while longer. Inevitably, returns on the investment have diminished. But thanks to Apollo, when people do return to the moon, they will know what questions to ask.

When you were a kid you made you
Maybe this is the year you ma

When We Last Saw Our Heroes...

In the 25 years since the Apollo astronauts explored the moon, their celebrity has brought them many Earthly rewards. But in some ways they're still the same old test pilots we adored.

by Andrew Chaikin

Based on the book A Man on the Moon: The Voyages of the Apollo Astronauts, *published by Viking, 1994.*

Alan Shepard, the first American in space, the fifth man to walk on the moon, is 70 years old. He can go to the movies on a senior citizen discount. Not that he needs to. As an astronaut, he was involved in a host of lucrative business ventures. By the time of his Apollo 14 mission in 1971, he was already on his way to becoming a millionaire. Today he owns homes in Houston and California's exclusive Pebble Beach, runs a Houston-based consulting business, serves on the boards of Kwik Kopy and other corporations, and is president of the Mercury 7 Foundation, created by the original astronauts to give scholarships to students interested in space and technology.

Shepard's career is typical of post-Apollo success. Scan the roster of Apollo veterans and you'll find captains of industry and men of influence. Pete Conrad, commander of Apollo 12, is a vice president of McDonnell Douglas. Harrison Schmitt, an astronaut and geologist on Apollo 17, is a former U.S. senator. Apollo 11 crew member Mike Collins presided over the creation of one of the most popular museums in the world, the National Air and Space Museum. Jack Swigert, who helped bring the damaged Apollo 13 spacecraft back from the moon, was elected to the U.S. House of Representatives before his death in 1982. Bill Anders, whose flight on Apollo 8 was the first to orbit the moon, is the recently retired chairman of General Dynamics as well as a former executive at General Electric and Textron, a former head of the Nuclear Regulatory Commission, and a former ambassador to Norway.

Even by this culture's special measure of success—media exposure—the astronauts have made it. Apollo 11 astronaut Buzz Aldrin has appeared on "Lifestyles of the Rich and Famous" and recently had a speaking part on "The Simpsons." Alan Bean, a crewman on Apollo 12 and now an esteemed artist, starred in a commercial for Actifed. Five moonwalkers were guests on Oprah. And every five years, when the anniversary of the first lunar landing rolls around, journalists scurry to write "Where Are They Now?" summaries like the one you've just read.

This post-NASA success should come as no surprise; the astronauts were overachievers before they were astronauts. The same qualities that helped them get selected by NASA—intelligence, energy, motivation—were assets in building new careers. But the moon voyages added another dimension. "You're given unrealistic opportunities that you wouldn't have had otherwise, and measured by an unrealistic yardstick," says Bill Anders, who as chairman of General Dynamics made *Fortune* magazine's 1992 list of the top ten highest paid CEOs. On Christmas Eve 1968, world news organizations carried Anders' voice reading from the Book of Genesis while his spacecraft orbited the moon. At post-flight banquets, people treated Anders and his crewmates like oracles, asking them about everything from the stock market to the prospects for world peace. Remembering the questions he fielded after his flight, Anders says, "Pretty soon it's

At 35, Bill Anders was one of the three Apollo 8 astronauts who made the first journey from Earth to the moon. With one of mankind's great adventures in your background, what do you do for an encore? At 60, Anders (opposite) has just retired as chairman of General Dynamics, the last of many powerful positions he has held in government and the aerospace industry.

easier to answer than to explain we don't know anything about it."

The astronauts had become charmed men, but the charm, they soon discovered, carried with it some unexpected and uncomfortable twists. "People *do* care what I do. I have to be very careful," says Al Worden, who piloted the command module on Apollo 15. "I can't go out and tell somebody out in public to 'Get out of my way' because it would be in the paper the next day."

Worden also says he's a target for "every charity in town." Like many astronauts, he has supplemented his income by making speeches—the asking price is usually in the $5,000 range—but most of the calls he gets are from people who "somehow think that I'm in the business of doing things for free."

Even now, decades after the astronauts became private citizens, many people still see them as public servants. "A lot of people think they still own us," says Pete Conrad, "and they don't understand why we won't get on an airplane and go halfway around the country [gratis].... The easiest way to counter that is to say, 'You want me to come? Fine, pay me enough.' I don't bother to explain that the reason I say that is because, number one, I don't have the obligation to do that; number two, I don't have the *money* to do that."

These are the afflictions of fame that all celebrities suffer. "The mail is still overwhelming," says Apollo 14's Ed Mitchell (and NASA doesn't pay for the postage to answer it). At least the astronauts aren't likely to be recognized on the street and hounded by autograph seekers. Their brand of celebrity makes them famous and anonymous at the same time, as Pete Conrad demonstrated in 1975. He was one of the first personalities that American Express used in its ad campaign based on highly ac-

complished but barely recognizable newsmakers. "Do you know me?" Conrad asked, smiling into the camera. "I walked on the moon."

The accomplishment for which the astronauts won renown was generally perceived as a life-altering experience. Seeing your planet *as* a planet, journeying farther from it than anyone, standing on another body moving on its own path in the solar system—surely that changes a person. But the majority of the astronauts will tell you they're basically the same guys they were when they became astronauts. Alan Shepard is said to have once quipped, "Before I went to the moon I was a rotten S.O.B. Now I'm just an S.O.B."

Pete Conrad was a 39-year-old Gemini veteran when he became the third man to walk on the moon in 1969. Today a vice president at McDonnell Douglas, Conrad (opposite) says his credo is "Don't look back." His Apollo 12 crewmate Alan Bean, however, does look back and, through his paintings, tries to show others what he saw.

Pete Conrad says he regarded going to the moon as a job—albeit the best job in the world—and he brought to his work the emotions not of an explorer but of a test pilot. He didn't have an innate desire to walk on another world, he says; the goal was to stand on the summit of his profession. By the time he went, he'd spent seven years preparing, mentally and physically, for the journey. But on the day in 1962 that he was selected to be an astronaut, he vowed that going to the moon wouldn't change him. Today, three decades later, he says he's kept that promise.

And he isn't alone. Stu Roosa, who made the journey with Apollo 14, says that viewing Earth from deep space and seeing the barren face of the moon had an impact on him, but it didn't change him. You can't see those things and not be affected, he says. But he adds flatly, "Space changes nobody. You bring back from space what you bring into space." And most of his colleagues agree with him.

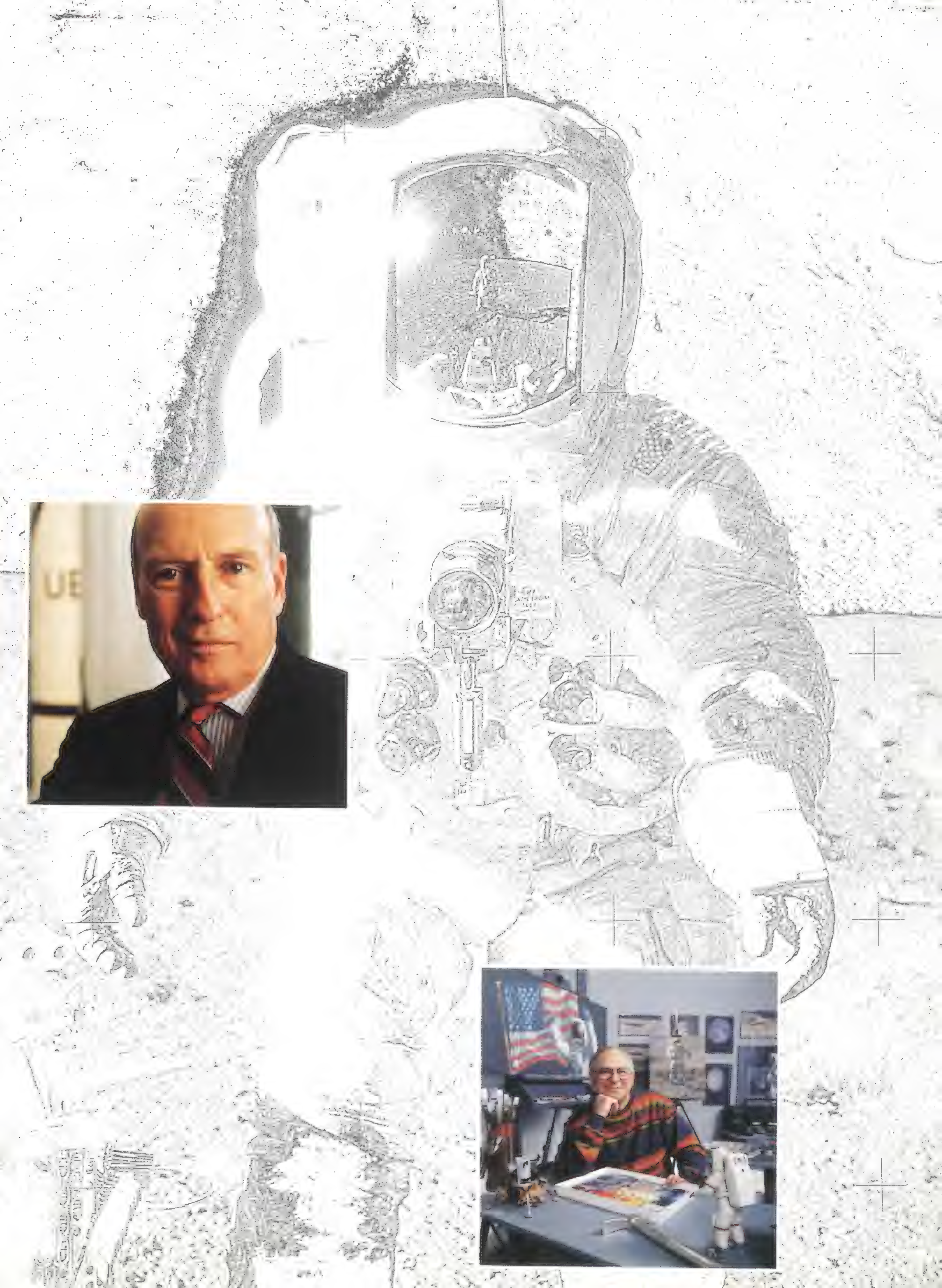
Roosa's words are ironic considering that the man who accompanied him and Alan Shepard to the moon—Ed Mitchell—says his whole sense of being was altered by the experience. Mitchell's experiments in ESP during his flight were covered by the press, but what was less widely known was that he experienced a dramatic shift in consciousness on the trip back to Earth. For the next 15 years, Mitchell strove to piece together an understanding of what had happened to him. Along the way, he founded the Institute of Noetic Sciences in Sausalito, California, devoted to the study of consciousness. Today Mitchell believes that an information field pervades space, like a cosmic data bank, and that it records the accumulated experiences of all matter, including living organisms, throughout history. When his awareness shifted on the way home from the moon, he says, he was tuning in to the data bank. Why didn't the other astronauts experience the same thing? They did, Mitchell says, but what they express "is shaped by our level of awareness, and by the filter we call 'belief system.' "

The only other astronaut who talked about his moon voyage as a life-changing experience was Apollo 15's Jim Irwin, who returned from the moon in 1971 and declared that he had felt the presence of God there. Within a year, Irwin's spiritual awakening led him to trade the cockpit for the pulpit, as founder of a Baptist ministry called High Flight. He spent the last two decades before his death in 1991 traveling all over the world to share his faith.

Spiritual awakening on a moonflight was not part of the image the astronauts had of themselves, nor was it part of the image the world had invented for them. Irwin ran afoul of the first with his religious conversion. Some of his colleagues would joke, "I don't know what happened to ol' Jim up there." He ran afoul of the second when he went along with a business proposal that would have brought him personal gain from his moonflight. Irwin's departure from NASA came in the wake of the disclosure that he and his Apollo 15 crewmates David Scott and Al Worden had arranged to sell to a German stamp dealer envelopes that they had carried to the moon and back. NASA reprimanded the crew and removed them from flight status.

In some ways, the hardest part of being an ex-astronaut has been living up to expectations—not only those of their fans but their own as well. Apollo 8 commander Frank Borman called his efforts to save Eastern Airlines his first failed mission. Borman worked seven years as a senior vice president before becoming the airline's chief executive in 1975. During his tenure, Eastern reversed its losses and earned profits from 1976 through 1979. But after deregulation, Borman found himself in a bitter power struggle with Eastern's unions—a battle he eventually lost. Today he lives in Las Cruces, New Mexico, a place, he says, where no one cares that he was president of Eastern or that he went to the moon. "I made it through some very traumatic times," he says.

Perhaps no moon voyager understands the pitfalls of expectations better than Buzz Aldrin. As an astronaut, Aldrin showed his mastery of spaceflight, not only by helping to pioneer techniques for space rendezvous but by making the most successful spacewalks of the Gemini program. Talking about it—especially about how it felt to fly in space—was another matter. By his own admission, Aldrin was never



comfortable in front of the microphone and did not relish the role of NASA spokesman that greeted him on his return from Apollo 11. Aldrin left the agency in 1971 to resume his Air Force career in command of the test pilot school at Edwards Air Force Base in California. As a non-test pilot with no managerial experience, he felt unable to perform up to his own high standards; his self-esteem eroded. Within a year he was hospitalized for depression. Two years later, he described his struggles against manic-depression and alcoholism in an autobiography, *Return to Earth*. Some reviewers criticized Aldrin's decision to make public his experience and in the process further debunk the myth of the perfect astronaut. But he was determined to tell the world what he went through and to let others with similar problems know that they have company, even among men who walked on the moon. Aldrin believes that his struggle was probably inevitable but certainly accelerated by the double jeopardy many astronauts faced: the sudden onset of world attention, followed almost immediately by the end of their spaceflight careers.

Today Aldrin's recovery is long complete, and he would much rather discuss the future than the past. At his Laguna Beach home, Aldrin is a one-man think tank on space exploration, designing anything from reusable launch systems to scenarios for lunar bases and Mars voyages (see "The Mars Transit System," October/November 1990). He doesn't work for an aerospace company, and he says he's not cut out for consulting work: "I don't want to tell the client what he wants to hear," he explains. "I want to tell them what I think." Instead of a livelihood, Aldrin says, his work is "an expensive hobby," which he finances as much as possible

When Ed Mitchell went to the moon in 1971, he and Alan Shepard spent nine hours exploring its surface.

by making personal appearances. He considers himself lucky to have experienced adversity. "I'm a better person for having gone through that," he says.

The transition from moon voyager to private citizen was rougher for some astronauts than others, but one curse from the journey found them all. Whenever their identities as Apollo astronauts are revealed, out comes the question that has plagued them for a quarter of a century: "What was it like to go to the moon?"

The astronauts have done their best to answer—in interviews, guest appearances, magazine articles, and a slew of autobiographies. Mike Collins, whose book *Carrying the Fire* was one of the first accounts of the Apollo experiences, found that even 400 pages of explanation didn't help. "They say, 'Oh, I loved your book! Now tell me—what was it really like up there?' "

Even when the astronauts try to respond, they find their listeners aren't always satisfied. "Usually if I tell 'em the truth, then they don't believe me," Conrad says, "because they've got some preconceived notion that I should tell 'em I was frightened, or I was awe-inspired, or I saw the Lord—or I don't know." Whatever they want to hear, Conrad says, it's not what he tells them: that when he was on the moon his strongest feeling was that it was the right place to be at the time. "That just shuts the door," he says.

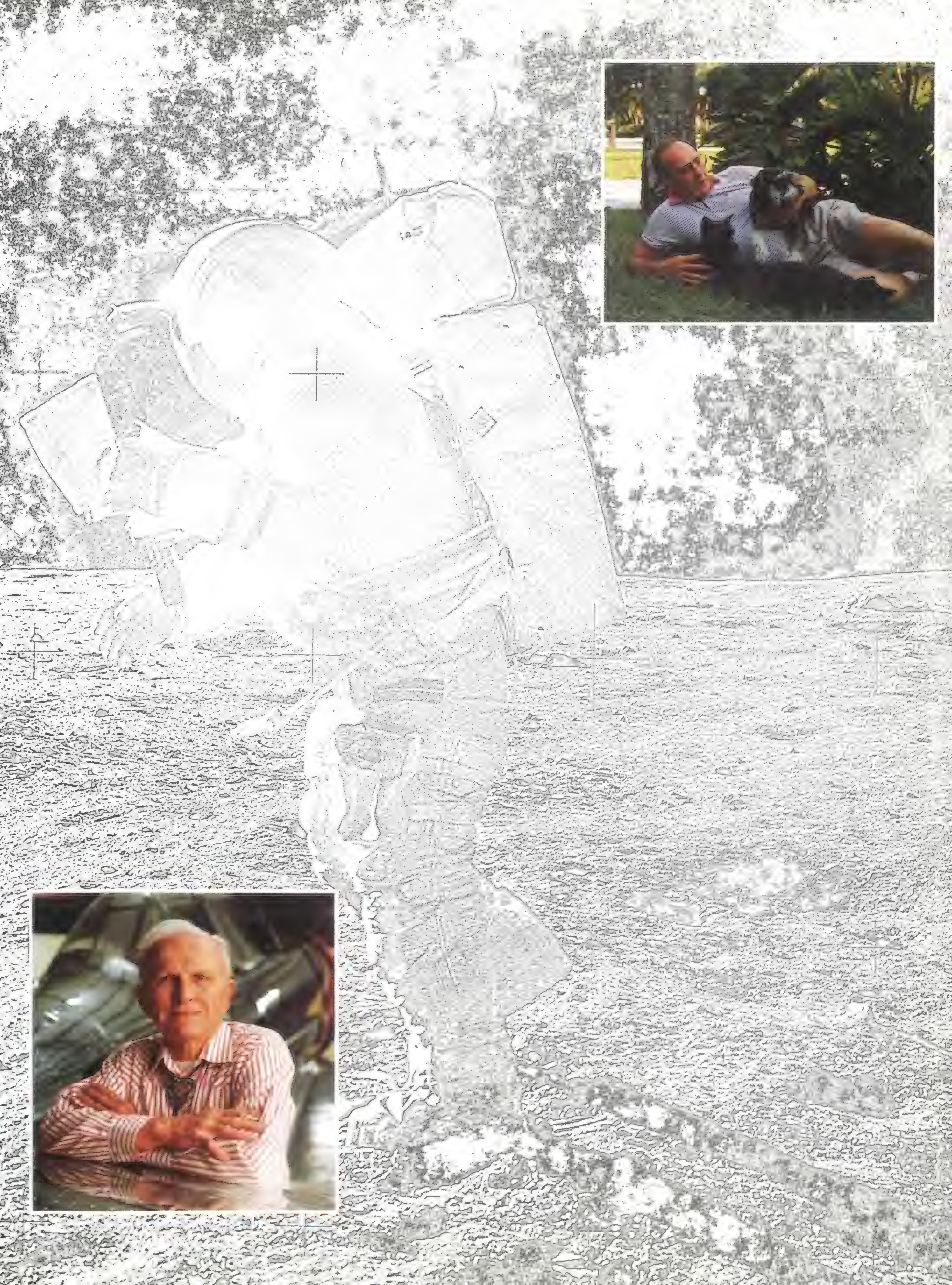
So does the thought of a man who has been to the moon and does not look at it. "That's the other thing drives people crazy," says Conrad. "They *know* I'm lying. They say, 'Don't you go out and look at the moon?' And I honestly don't."

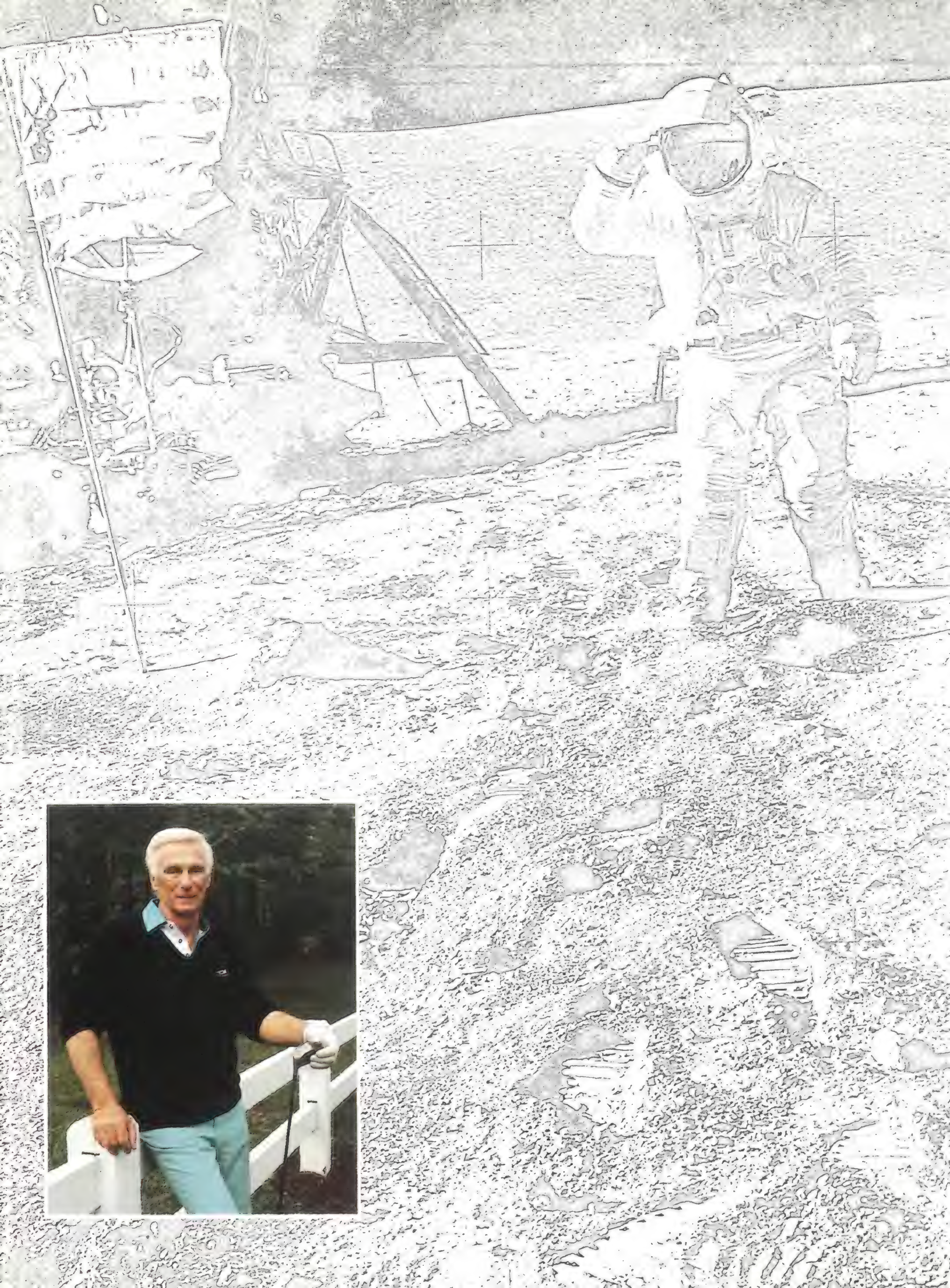
Maybe that's because Conrad's most cherished memories of space didn't happen on the moon. When someone mentions space, he says, it isn't his Apollo flight that comes to mind; he thinks of his mission to repair the crippled Skylab space station in 1973. But it's the moon that people want to hear about, and when Conrad gets the question *What was it like?* he gives the neat, two-second answer he developed long ago: "*Super!* Really enjoyed it."

Why do people still care how the astronauts feel about something they did so long ago? Having spent eight years talking to the moon voyagers, I can speak for myself. Through them, somehow, I wanted to touch the experience. I listened for that magic combination of words that would show me the Earth afloat in a starless black, or let me leave my own footprints in lunar dust. But after 25 years, that's asking more than most of them can give.

For a vicarious seat on a lunar mis-

Astronaut Frank Borman commanded the successful though arduous Apollo 8 mission when he was 40. Today Borman (opposite) and Ed Mitchell (right, top) live in relative leisure—Borman in New Mexico and Mitchell and friends in Florida.





sion your best bet is an audience with Gene Cernan. Tall and white-haired, Cernan has the larger-than-life presence of a celebrity. Even now, he still looks the way people expect an astronaut to look. And as a veteran of two lunar voyages, including the final moon landing in 1972, he is keenly aware of his membership in an elite group of human beings. He confesses irritation when astronauts and cosmonauts who have "only" orbited Earth wax poetic about the fragile beauty of their world: "They've never seen it! These guys have never seen our Earth."

One of the more openly emotional men in the astronaut corps, Cernan has always believed that it was crucial for the astronauts to bring back from the moon "something besides rocks." Today, he frequently takes time out from his Houston consulting business to share the experiences of a space traveler. One evening at a high school in Acton, Massachusetts, Cernan's audience spanned two generations. To the parents, he stressed the importance of education and the need for the country to find a goal in space to mobilize its technology and capture the public's imagination.

All this time the children listened quietly; then it was their turn to ask questions. A young girl asked how far he could jump on the moon, and Cernan lit up: "That's a good question! Does anybody know what gravity is?" He'd shown some nervousness before, talking to the adults, but it was gone now, as he explained to the children how he opened a can of peaches in zero-G and turned it upside down while he ate. "If you want to be a spaceman," he said mischievously, "go home tonight and try it." Cernan continued to answer questions until a little girl asked the old standby: "What does it feel like when you're on the moon?"

Cernan smiled and bowed his head for a moment before trying, yet again, to find an answer: "You can move around very easily in one-sixth gravity, so it feels very comfortable. You're not warm, because your suit is air-conditioned with water." Abruptly he stopped and tried a different approach, one from the heart.

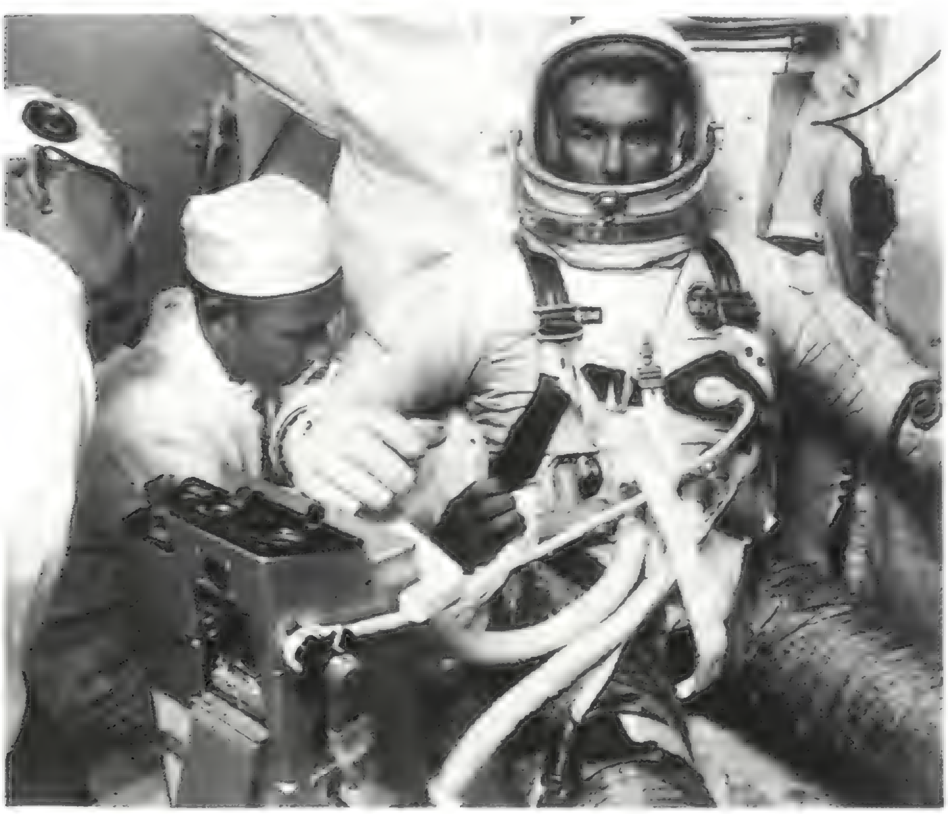
"I'll tell you what it feels like. It feels like you're dreaming. You wonder when you're going to wake up. It's almost like your mom told you a wonderful story before you went to bed and, you know, sugar plums—it's like Santa Claus has already come. Being on the moon is like Santa Claus just gave you your wish."

The first man to get that wish is the most famous and among the most private of all the moon voyagers. Neil Armstrong turns down most requests for interviews. At most astronaut reunions he is notable for his absence. And to that extent he has lived up to the expectations of his colleagues.

No one who knew Armstrong was surprised when, two years after becoming the first person to walk on the moon, he left NASA for a farm in his native Ohio and a post as a professor of engineering at the University of Cincinnati. But he has hardly been a recluse. In 1986 he served as vice chairman of the presidential commission to investigate the *Challenger* disaster. He has appeared in advertisements for Chrysler and has hosted a cable TV documentary series on the history of flight. He gives assistance to historians who research the Apollo program. Some in the space community have wished that he were a more visible spokesman for space exploration, but most praise his approach. They say Armstrong was the ideal choice for the role of first man on the moon, as if it were an office to be filled. Were he more visible, they say, he would cheapen its currency. Armstrong has said that he considers fame a direct result of media exposure and that he has received a disproportionate share of it. One moonwalker says that when it comes to fame, if the astronauts were football players, they would be a high school team, and Armstrong would be "the only guy in the NFL."

Five years ago, all three Apollo 11 astronauts attended NASA's celebrations to mark the 20th anniversary of their mission. And along with a dozen of their colleagues, they were on hand at the White House after George Bush announced the Space Exploration Initiative. Armstrong has already told NASA that he won't participate in reunions this summer to mark the 25th anniversary of his historic step. Of course, if the president decides to make a speech about space, he might just summon Armstrong and the other moon voyagers to the White House, and they will probably go. Even after 25 years, the most powerful endorsement a leader can invoke for a program of space exploration is the presence of an Apollo astronaut.

Commander of the last and longest moon voyage, Apollo 17, Gene Cernan spent three days on the moon in 1972. Twenty-two years later, Cernan (opposite) still enjoys describing those three days and has no shortage of invitations for public appearances.



Birds of a Feather

When a flock of geese bonded with an ultralight, the pilot became leader of the pack.

by Karen Jensen

Photographs by William Lishman and Joseph Duff

It's easy to regard Bill Lishman as a man who has everything. The 55-year-old Canadian is a metal sculptor of international renown and an inventor who designed his own underground home—and even his own refrigerator. But Lishman nonetheless views himself as somewhat wanting: it was his misfortune to be born without wings.

Ever since he was a child watching gulls swoop behind his father's plow, Lishman has wanted to experience their freedom and nonchalant comfort in the air. He tried to capture the feeling by learning to fly in an aged Cessna 150 but gave up after spending, as he recounts it, "a few expensive, nervous hours in that vibrating tin box looking out through crazed plastic and listening to shouted instructions and garbled radio, hoping that I hadn't missed some critical piece of static." That kind of flying wasn't what he was looking for.

So he tried another tack, learning to fly, he jokes, "the Wright way"—leaping off the grassy slopes around his Blackstock, Ontario farm beneath a variety of hang gliders. He eventually attached a small engine to one when he got tired of carrying it back up the hill, and began feeling his way through the rudiments of powered flight.

One day in 1984 Lishman was flying his cobbled-together ultralight around the countryside when he happened upon a field that was dark with birds. Curious, he moved in for a closer look. Suddenly the birds exploded upward. "The next thing you knew I was in the midst of this huge flight of ducks," he says. "And that was so exhilarating that I decided I've got to pursue this further." If he couldn't fly like the birds, perhaps he could fly with them.

Lishman sought out naturalist Bill Carrick, a distant neighbor who had trained birds to follow a boat for a scene in an IMAX film. Carrick taught him to take advantage of a natural phenomenon called imprinting, in which the young of some bird species will follow anything they see within their first 24

Canadian flier Bill Lishman uses a "trike" ultralight customized to goose standards with a propeller guard, large wing, and lightweight engine. It seems to suit the birds to a V.

hours. Usually it's their mother. In this case the birds would imprint on the lanky figure of Lishman and some odd paraphernalia: the gawky shape of an ultralight aircraft and a tape recording of the insect-like droning of its engine.

As it happens, ultralights are highly suitable for such a mission, because they are the only airplanes capable of flying slow enough, and even they need to be modified to cruise at what Lishman calls "goose speed"—about 30 mph. "We humans have had envy of birds for so long because of their freedom to go wherever they want, and it's only in this last century that we've been able to get up in the air," he says. "And then we all got going too fast." Even the 1905 Wright Flyer, which flew at 40 to 50 mph, would have been too fleet for Lishman's purposes.

It took two years of experimentation with birds and aircraft before Lishman's efforts paid off. In 1988 he raised a brood of Canada geese, exposed them from their very first hours to the sights and sounds of an ultralight, and conditioned them to follow as he pulled a mockup aircraft around his grass landing strip and, eventually, as he flew. It was a first in both aviation and ornithology. "A lot of us have these harebrained ideas, and Bill just pursues them," says Toronto photographer Joe Duff, a longtime ultralight buddy of Lishman's. "And once he pursues them for a while they're not harebrained anymore."

Carrick saw something valuable in the achievement. If the birds were willing to follow Lishman around his home, maybe they'd also follow him on a longer journey. This raised the possibility of teaching endangered birds such as whooping cranes and trumpeter swans new migration routes to wintering grounds safe from disease and

Drawn to the sound of the ultralight engine recorded on tape, the geese followed Lishman and his daughter around the family's farm north of Toronto.

human intervention.

Lishman and a group of volunteers put the idea to the test. Last October the sculptor and Duff led 18 Canada geese about 400 miles south to a winter home in Warrenton, Virginia. The journey took seven days, including three spent waiting out bad weather, with the birds flying up to four and a half hours a day. Once or twice during a leg, Lishman and Duff would trade off flying the positions of "goose leader" and "goose chaser," as their identical aircraft are called, to give the pilot flying the more tiring leader position a break. Staying in sync with the birds as their leader requires making constant throttle adjustments and flying with one's arms extended to push forward the control bar attached to the hang glider-like wing. This increases the wing's angle of attack, which slows the aircraft.

Lishman and Duff didn't know whether

CAROLINE SHEEN

Lishman and fellow pilot Joe Duff flew a pair of modified ultralights, one leading and one following the flock, and occasionally switched positions to relieve each other from the somewhat arduous duty of flying the lead position.

they would need to show the birds the return route in the spring, or if they'd be able to find the way back on their own. In the wild, Canada geese are taught migration routes by their parents, who've already made the trip.

Then, one Saturday in early April, just as the pilots assumed they would have to lead them home, the birds vanished. ("We don't say they're gone," says ever-precise waterfowl expert Bill Sladen, the project's scientific director. "We say we have not seen them.") When the birds hadn't been seen for over a week, concern grew. The pilots gave them a few more days and then, with bad weather threatening, packed up the airplanes and began driving north, checking every site they and the geese had stopped at on their way down.

As time passed, the exercise seemed increasingly futile. "All these doubts are nagging at you," Lishman says. "You think, *How are they going to find their way back? When we flew south, were they just following the wing, or did they really know which way they were going?*" As they neared Albion, New York, the first stop they had made last fall, Lishman called ahead and got good news: his wife Paula had spotted more than half the flock on the runway that morning. The remaining birds were presumed to be in transit. "We had to pull off the road and jump up and down for a while," the still-elated Lishman says.

The real test will come this fall, when Lishman and Duff hope the birds will make the migration south completely on their own. Eventually, the principles learned by working with common birds could be applied to endangered ones. Lishman and company next plan to work with sandhill cranes as a precursor to establishing a new migration route in a flock of rare whooping cranes.

The early stages of the goose project, including assembling and testing their modified trike-style ultralights while working with the young birds, were the most trying. "For several months we lived and breathed gas fumes and goose poop, grew hoarse with attempted goose calls, froze our fingers, and never ever got enough sleep," Lishman says.

Complications kept cropping up down to the last days of preparation. About a week before they expected to depart on the southerly flight, Lishman and Duff decided to do a run-through of the departure scenario with everyone involved, including their ground crew and a crew in a boat and an amphibious airplane that would monitor their 36-mile flight across Lake Ontario.

To customize their aircraft for the trip, the pilots had outfitted one with a smaller wing that would allow the goose chaser to fly at between 30 and about 50 mph and the other with a bigger wing to accommodate the leader's speed: between 25 and 40 mph.

"We released the birds and they just *took off*," Duff says. "They were flying at 45 miles per hour. And Bill was flying the slow wing. It's called an Atlas wing, and no matter what you do with that wing, you cannot make it go past 40 miles an hour. You can pull it in and suck your stomach in and get it going straight down and add power, and it just goes up. It just will not fly faster than 40. So the birds were passing him like crazy."

"We were just fit to be tied because we'd never had them fly at that speed," Lishman says. "They were 15 miles an hour faster

Occasionally the geese trail tidily behind (below), but usually they fly their trademark V formation off the ultralight. When the air is still, the formation tightens up (bottom), much to the pilot's delight.

than they'd ever flown before. It was just a total curve. It was like we were ready to win the World Series, and the players suddenly want to go out and start playing basketball or something."

They talked about the problem late into the night and decided to try equipping both craft with fast wings. One of Lishman's assistants also added two D-shaped extensions to the wings' control bar so that the pilots wouldn't have to hold their arms out so far, making slow flying with the fast wings more comfortable. "The next morning we got up, just the two of us, nobody else was there," Duff says. "[We] took off with the birds and we flew about 20 miles there and back and the birds flew right off the wing—just perfect."

They later attributed the birds' burst of speed to an increase in fitness and food intake as the time for migration neared, as well as to the last-minute addition of five new birds to the flock. Not wanting to take any chances with the migration flight, they left those five in Canada, and after a fast start, the remaining 18 resumed their normal speed for the rest of the trip.

For both pilots, the highlight of the journey was, of course, flying with the birds, though Lishman and Duff did have to learn to compensate for the birds' presence in the air. "For instance, if all the birds line up off your right wing, it deteriorates the lift on that wing and actually pulls the aircraft to the right," says Duff.

The birds also like to ride on the pressure wave created in front of the aircraft. "You see, they're always looking for the most efficient way to fly," Lishman explains. "I've had half a dozen right across the front. Just give it a little more power and they'll sit there and ride on that leading edge taking some power from the aircraft. But you have to add some power or you start going down. And they are all flapping together; it sets off a wave and so the whole aircraft is vibrating to the same wing beat."

The course of the experiment so far hasn't been entirely poetic. Tension developed between Lishman and Carrick, with Carrick eventually deciding to go his own way. "I complained about him taking over the project and he told me I couldn't do it without him," Carrick says. "And that was a challenge I couldn't refuse." The naturalist is now pursuing a project to condition trumpeter swans to follow ultralight aircraft.

But Lishman's preliminary work has already excited conservationists. "The significance of the work done is that it points to the future, to what can be done," says David Ellis, an animal behaviorist with the Patuxent Wildlife Research Center in Laurel, Maryland. "It's hard for me to imagine an ornithological development that had a greater significance to conservation. It's like the development of a decade."

The emotional sensation of joining a flock of birds is one Lishman still has a hard time putting into words. "When you get up flying with the birds, somehow you have that feeling that you've been flying over this planet for a million years. I mean, you see the planet in a really primal way," he says. "One time I was looking down and there was a wing out there, and a wing out there. And this one flying right underneath me, just so close," he says, gesturing to imaginary birds all around him. "It was like I had my own wings."

The first leg of the human-led migration, from Toronto over Lake Ontario, went according to plan. But would the geese make it back to Canada on their own? After wintering over in Virginia, they vanished in early April.

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THE LATEST WORD ON TOURS, EXPEDITIONS AND LEARNING ADVENTURES

The Tip of the

The last outpost of the cold war maintains a vigil on the Korean peninsula.

The fumes of jet exhaust that linger over Kunsan Air Base in South Korea are oppressive evidence that the cold war isn't over yet. Last winter recalled that tense era as North Korea and the United States engaged in brinkmanship over North Korea's refusal to allow inspection of its nuclear sites. As tensions persisted into the spring, the diplomatic standoff served as a reminder that it was an armistice—an armed peace—that suspended the Korean war on July 27, 1953.

"Kunsan is the last bastion of the fighter pilot," says Colonel Steve Trent, commander of the Eighth Fighter Wing. The Wolf Pack, as the fighter wing is also known, flew combat missions in the original Korean conflict and participates in "Team Spirit." These on-again, off-again military exercises, originally scheduled for last spring, are designed to annually refine coordination of U.S. and South Korean military forces—as well as send a message to North Korea.

If the rehearsal ever turns to the real thing, the primary mission of the fighter wing's 52 F-16s will be air support of ground forces. In addition to their ground attack mission, the two fighter squadrons that make up the wing—the 80th and the 35th—will have to quickly establish air superiority. A squadron of 24 F-

Flanked by the Yellow Sea, the 8,800-foot main runway at Kunsan Air Base in South Korea points—appropriately—north. The two squadrons of Air Force F-16s that use it (below) can reach the North Korean border in less than 20 minutes.

Sword

by Tom Harpole

Photographs by Geoffrey Clifford

Pilots sign up for one-year tours at Kunsan. After they're gone, their photos are posted in the pilots' lounge (above). In the event of war, the primary mission of the F-16s will be "air to mud"—dropping bombs in support of ground forces.

16s stationed at Osan Air Base near Seoul will augment the Kunsan fighters, while a squadron of A/OA-10s from Osan would act as forward air controllers, identifying targets and directing F-16 bombing missions.

"Our job is to prevent [North Korea] from overrunning the south," says Trent. "But we'll do more than support ground troops. We have targets up north we'll destroy too." Trent speaks with a halting delicacy that seems incongruous for a former commander of the Thunderbirds, and his consistent use of the future tense when he speaks of hostilities adds an ominous note.

Kunsan is the most remote post in the peripatetic career of an Air Force fighter pilot, and the isolation creeps into the outlook of those who are stationed here. "The Kun isn't the end of the world," says one pilot, "but you can see it from here." Occupying approximately four square miles overlooking the Yellow Sea on the west coast of the Korean peninsula, Kunsan Air Base is located about 125 miles south of the 38th parallel, which has been the dividing line for the Republic of Korea and the Democratic People's Republic of North Korea since 1945. Bisecting the base is an enormous concrete "T" formed by the intersection of the 8,800-foot main runway and a shorter secondary one. Base personnel reside on one side of the secondary runway. On

The 35th Squadron and its sister squadron, the 80th, belong to the Eighth Fighter Wing, which last saw combat action in Vietnam. At 41, Lieutenant Colonel Fred Offutt is one of the 35th's older pilots.

the other side, the "Vipers," as the pilots call the F-16s, are individually housed in scattered mud-brown Quonset huts that have been concrete-hardened for protection. A squadron of Korean air force F-5s occupy nearby hangars. Operations buildings, maintenance hangars, munitions bunkers, a fuel storage area, fire lookout, and control tower complete a grid of buildings on that side of the runway.

The F-16s make Kunsan a prime target for a North Korean attack to "degrade our sortie generation," in Trent's words. During Phase One Alert exercises, camouflage netting is draped over the entrances of various base facilities to obscure the names of buildings. North Korea has several hundred An-2 Colts, old Soviet biplanes that would attempt to drop paratroopers inside the base. In addition to an air invasion, semi-submersible landing craft are expected to come ashore from the Yellow Sea and deploy commandos.

North Korean frogmen have invaded the beach at Kunsan at night. Four miles out in the Yellow Sea, a half-dozen mountainous islands loom in the haze. They are littered with ration cans the North Koreans have left behind. On the beachhead, South Korean soldiers sit with loaded weapons in bunkers spaced roughly a quarter-mile apart. The only other visible means of security is a chain link fence that might just as well surround a construction site.

Fear of infiltrators, a language barrier, and the Americans' brief one-year tour discourage cross-cultural rapport on the base. Trust of the Korean civilians is thin, and the Americans and the Koreans stationed at Kunsan live like two closed societies that share a common enemy. Several of the younger pilots eschew the services of housekeepers in their dorm, afraid they could be North Korean infiltrators. Just a $4.50 taxi ride away from the base lies "A-Town," a squalid, sloping alley lined with tiny Korean eateries, bars, and strip joints where small, hard women in modest bikinis hint at after-hours trysts, which, if indulged in, would be the closest most Americans here ever come to socializing with their allies.

The air base employs some 3,000 people, fewer than serve aboard a large aircraft carrier. Their living quarters consist of earth-tone metal and stucco buildings on streets lined with juniper trees that have been so severely pruned they resemble poodle tails. Outside the two-story pilots' dorm the parking lot is full of rusting Japanese right-hand-drives, bald-tired Korean beaters, and 20-year-old Detroit gas guzzlers. The hundreds of bicycles on the base seem like far more reliable transportation.

The sense of isolation at Kunsan is conveyed in its reputation as "the tip of the sword, the end of the food chain." It's one of the Air Force's last remaining one-year unaccompanied assignments—housing is not provided for a spouse. To allay their loneliness, people routinely work 12 or more hours a day. Kunsan City and its 250,000 inhabitants are a 30-minute drive from the base but hold little interest for the Americans. They will, however, drive three hours north to Osan Air Base to eat at the Burger King. Otherwise the fighter pilots occupy themselves when off duty by running, playing basketball, or lifting weights to increase G-tolerance. Another pastime includes grip-

ing about conditions on the base: the power and water outages, the paucity of fresh food at the commissary, and the "new" air force.

Miss Chae, the flirtatious Korean woman who has run the bar at the officers' club for more than 10 years, also bemoans the ways the air force has changed, which she blames for the lack of customers. She reminisces about pilots who used to ride motorcycles into the lounge and take off their clothes. The glass was broken so often they had to install clear plastic in the windows. She tosses her permed mane and snaps a dishrag over a dark sink. "Fighter pilots are a bunch of afraid-to-have-fun dickheads now," she says.

I arrived at Kunsan last December at the invitation of my cousin, Major Mark Harpole, a pilot for the 35th squadron. "This place is a shithole," he shouted above the roar of the armored personnel carrier that drove us around the base, "but we fly a lot."

Indeed. The air at Kunsan is so saturated with jet fumes that during 10 days there I never smelled the sea. Every few minutes speech is arrested by afterburner takeoffs or the whistling shriek of an F-16 idling down the taxiway. By midday smog fills the air.

It's said that cockpit time adds up faster at Kunsan than at any other base

Favorite ornaments decked an artificial tree last Christmas at the officers' club, where Miss Chae serves as bartender and sympathetic ear (left). Bicycles are a popular way to get around the base; when not flying an F-16, Major Mark Harpole rides a Schwinn (below). Between missions, the F-16s are housed in concrete-hardened Quonset huts, and Captain Kelley Tabor gets time to practice his cooking (opposite).

in the world. A common malady here is "G measles," a purple rash of burst capillaries, often appearing on the elbow and buttocks, caused by pressure on the vascular system from G-forces. The Viper drivers are a varied lot: majors who got sick of Pentagon desks, Desert Storm vets, and guys trying to fill in their resumes. "We get captains who have always heard about 'the Kun' and want to come here to get the flying time," says Trent. In the post office, base exchange, bowling alley, and gym it's not uncommon to see a group of pilots standing in a circle and flying tactics with their hands. From a distance the men almost appear to be dancing.

Flying conditions are good at Kunsan. The cold winters and warm summers are no different from home for many Americans, and the weather grounds the Eighth Fighter Wing less than ten percent of the time, rarely for an entire day. The base averages over 50 missions daily. Any given mission might combine elements of dogfighting, strafing, dive-bombing, radar evasion, formation flying, emergency landings, and air-to-air refueling. Pilots fly 15 to 20 multi-task sorties a month, which adds up to more than 12,000 F-16 sorties tearing off the runway a year.

In addition to flying exercises, Kunsan pilots serve as a deterrent force. In 1953 North Korean president Kim Il Sung vowed that he would reunify Korea in 40 years, and military intelligence takes him seriously enough to refer to an upcoming "second half" of the Korean war. "It's worth paying attention to promises from a totalitarian," says Steve Trent, adding, "it's good to know

"The Kun" (above) occupies approximately four square miles on the west coast of the Korean peninsula (map, opposite). South Korean troops provide security against the threat of invasion. Fear of North Korean infiltrators is constant.

you have a mission."

The neighbor to the north would be a formidable foe: 1.1 million North Korean troops compared with 633,000 South Korean and 34,830 U.S. troops. The North has at least a two-to-one advantage over the South in artillery, and they are currently developing two long-range missiles, Taepo Dong-1 and Taepo Dong-2. "Saddam had the world's fourth largest army," says Trent with emphasis on the past tense; "now the North Koreans do."

In the air the North Koreans have 800 Soviet-built MiG fighter jets, mostly older MiG-19, -21, and -23s. The strongest air-to-air challenge consists of several squadrons of MiG-29 Fulcrums, which are capable of staying in a dogfight with an F-16. "The MiG-29 has a nine-G airframe like ours and a serious engine," says Captain Kelley Tabor, "but they don't know how to use it. We get way, way more cockpit time." In contrast to the heavy flying at Kunsan, fuel shortages restrict North Korean pilots to only one practice sortie a month. "They can't be proficient at starting their planes," Trent says half-seriously. Though not as severe, similar shortages constrain U.S. pilots, and pilots fear they may worsen.

But the Wolf Pack won't go looking for dogfights; their mission is primarily "air to mud." "We'll deploy our airplanes as bombing platforms, in support of ground troops," says Trent. Being at the "end of the food chain," however, limits what ordnance is available. "All our bombs are free-fall munitions," says Captain Matt Young, who flew in the Gulf war. "We don't have laser-guided stuff here. We should. Free-fall munitions are more accurate when we deliver them at low altitude. The North Koreans have a lot of heavy stuff down low. The triple-A [anti-aircraft artillery] is real lethal. It's worse than the surface-to-air missiles. It's too bad that all we have are these bombs we're supposed to deliver at low altitude. But when it starts," he says, "we'll own the air."

Captain Floy Ponder, who smokes cigars and has logged more than 2,000 hours flying fighters, has another perspective: "Bombs. Huh. We should drop a couple million Sears catalogues up there and show 'em that socialism ain't working."

"We aren't invincible," Tabor later says in the benchless locker room where the pilots change for flying. He looks down, rubs his flat-top, and then re-

vises his assessment: "Actually, with our equipment and tactics we damn near are."

The most widely accepted theory on the next invasion assumes it will stream down the same corridors used on June 25, 1950, when Kim Il Sung ordered armored divisions and troops south across the 38th parallel. The serpentine border that winds 150 miles across the Korean peninsula was established in 1953 as the Military Armistice Demarcation Line. Dozens of rivers—the Han, Kum, and Naktong are the biggest—flow across its western half from North Korea down into the flatlands and estuaries around Seoul. In 1950 these river basins provided passage to the invaders from the north. It's anticipated that a second invasion would come in the winter, when the swamps and rice paddies are frozen enough to support troop movements and the seasonal clouds would impede the F-16s from finding targets.

I had an opportunity to see this area when I was invited to accompany Lieutenant Colonel Fred Offutt on a routine sortie to Prohibited Area 518, the buffer zone south of the Demilitarized Zone, where the Eighth Fighter Wing likes to show an hourly presence, "just to show them we can," says Offutt.

After six months in Korea, Offutt still hasn't seen a MiG. But all along the heavily fortified border, surface-to-air missile batteries in hardened bunkers occasionally lock their radar on an F-16, lighting up the airplane's warning system. All the pilot can do is reluctantly retreat and file an incident report.

It takes less than 20 minutes to fly north, and I sat in the rear of an F-16 like a dog in the back of a car—hopeful, mute, and understanding few words. Earlier I had asked Offutt how long it would take to do a preflight briefing that was intelligible to a civilian groundling. "Hours," he replied. "No, weeks...no, years...." And finally: "It takes about six years to speak F-16 fluently."

Offutt pointed out the DMZ northeast of Seoul: steep watersheds falling south from a snow-dusted craggy range known as the Taebaek-sanmaek. Four tunnels, each big enough to move tanks three abreast, have been discovered under that range. Military intelligence estimates that another 20 tunnels are being excavated. Just over this natural divide, North Korea appears as a treeless, brooding mountainscape.

Offutt took us down on the deck—100 feet above the sparsely covered slopes of South Korea—to practice radar evasion through mountainous terrain. For 20 minutes we skimmed ridges and tore down valleys. Houses on terraced hillside farms were a blur just 60 feet off our wings. We pulled up hard over a pair of power lines on a bald ridge and climbed above an urbanized valley.

Most of the multi-task sorties flown out of Kunsan include bombing practice at offshore ranges, such as Kooni Rock, which is in a bay about a mile from the coastline. On this narrow, crescent-shaped reef, a Chinook helicopter has deposited old cars to serve as targets for the F-16s. On our trip back south to this practice range, the radio came alive with a stream of Korean. Offutt explained that air traffic controllers were grounding all South Korean aircraft while President Kim Young Sam flew to Osan. Because of the probability that North Koreans have infiltrated the South Korean air force, all aircraft are grounded whenever the presidential airplane is in the air, Offutt said.

We engaged in a mock dogfight over the Yellow Sea with Offutt's wingman, Captain John Kane, then headed for home. Offutt pointed out one of the dozens of highway landing strips—two-mile straight stretches built into the highway system to handle emergency landings. "I hate driving those highways," he said, referring to the anarchy that passes for traffic in South Korea. "I can't imagine landing a jet on one."

Once we had landed and were taxiing back to the hut, Offutt chatted on the intercom: "One point six hours...typical sortie...great dogfight...pretty country, isn't it? Politicians start something, we're ready." He turned the radios off. I could hear him breathing deeply on the intercom. "Pilots give all their quarters to keep doing this," he said. "If this wasn't a passion—what you live for—you wouldn't put up with the Air Force."

Despite Kunsan's drawbacks, it offers pilots one great attraction: a lot of flying time in the F-16.

The threat from the North ebbs and flows like the Yellow Sea on the slate-gray tidal flats next to Kunsan's main runway. And there's another nemesis pilots at Kunsan face almost daily: fuel shortage. "We're so low on fuel they say we'll run out before the end of the fiscal year next October," says Mark Harpole.

Supplies are another constant concern at Kunsan. "We're the deterrent against the most immediate threat in the world," says Harpole, "but the war here is with parts supply." One afternoon during my visit, six F-16s were scheduled to fly basic flight maneuvers. Four of them were held up, disqualified by a generator problem, a bald tire, an empty halon bottle, and a fuel leak. The remaining two jets finally made it off the runway and improvised their maneuvers.

Perhaps the lack of fuel and the condition of the aircraft only reflect the last gasp of the cold war. And perhaps somebody forgot to tell the North Koreans. Ultimately, it won't matter to the pilots at Kunsan. "We bitch a lot, but we can't wait to go north," says Lieutenant Dave Hlatky, who at six-foot-five and 290 pounds is the world's biggest fighter pilot. "Fighter pilots are like boxers who spend their lives training," he says as he steps into the Daewoo van that will haul him to his jet. "Korea's the place for the real prizefight."

Who needs tons of fuel and fancy guidance systems to travel through space? A handful of do-it-yourselfers say...

We'd Rather Be Solar Sailing

by Frank Kuznik

Cross Christopher Columbus with the Wright brothers and what do you get? Vladimir Syromiatnikov, father of the first sun-propelled spacecraft and leader of a potential revolution in spaceflight.

Or at least that's what the Russian space scientist is being hailed as these days by devotees of solar sailing, a radical idea for freeing space exploration from the bonds of conventional fuel requirements. Solar sailing may be the most exciting space propulsion system never to get off the ground—until, that is, Syromiatnikov popped open a disk-shaped sail in low Earth orbit last year.

Chances are, most space watchers missed that epochal event, since it was billed not as the unfurling of a solar sail but simply an attempt to reflect a patch of sunlight onto the night side of Earth. It wasn't very successful in that regard, as cloud cover was extensive that day. Nor did the sail glide on to explore deep space, since at an altitude of 250 miles it was too low to escape the drag of Earth's atmosphere.

But Syromiatnikov got it up, by God, and got four orbits out of it. To some, it was nothing short of a cosmic Kitty Hawk—"a fundamental breakthrough in how to do planetary science," in the words of Washington-based space consultant Klaus P. Heiss.

Others had a decidedly cooler take. "It was a stunt," says Ivan Bekey, an advanced-program planner at NASA's office of space systems development. "In terms of practical implications, it didn't prove anything."

But that, Bekey is quick to add, doesn't negate the technology's potential. "I think solar sails are a very exciting and very promising idea, and given some technology work, they will probably find a niche in our tools for moving around in space," he says. But for now, NASA is unwilling to invest in solar sails until the technology matures.

Like Columbus, however, solar sailors aren't about to wait around for an imprimatur from the scientific establishment. If anything, NASA's reserve has only fired their enthusiasm to pursue their schemes outside the space bureaucracy, as much to demonstrate its ineffectiveness as to prove their ideas. "When it takes 25 years to do a project and then it doesn't always work, there's something wrong with the structure of the U.S. space program," declares Heiss, a tall, commanding figure with an Austrian accent. "With private financing we can build and launch a solar sail within two years, and liberate space research from government funding."

The idea of solar sails dates back to the mid-19th century, when James Clerk Maxwell, developing his theories on electromagnetic radiation, posited that light exerts pressure. In the 1920s Russian scientists Konstantin Tsiolkovsky and Fridrikh Tsander proposed applying Maxwell's theory to spaceflight. If light exerts pressure, they reasoned, then it should be able to propel a large reflective object through the vacuum of space, where there is no resistance. (The pressure would be exerted by sunlight—not, as one might expect, the solar wind. The latter is composed of high-velocity particles like protons and electrons, which would exert little force on a solar sail. Light, on the other hand, is made up of bundles of pure energy called photons. When sunlight hits a sail, the photons move the sail in one direction—pressure—and the sail bounces the photons in another—reflection.) In the 1970s the theory hardened into fact when the U.S. probe Mariner 10, equipped with tilting reflective vanes, used solar pressure to help maintain its attitude.

Like other spacecraft, a fully operational solarcraft would make its way through space by orbiting. But a so-

The World Space Foundation envisions sunlight slowly but surely propelling a simple sail from Earth orbit into deep space.

larcraft would use sunlight to expand, contract, and reshape its orbit. If you speed up an object's orbit you'll raise its altitude, so if you launch a solar sail into Earth orbit and angle it to get a good strong boost from the sun, it will move into ever higher orbits. Eventually it will get far enough out to enable further modifications of its trajectory: it could pick up a gravity assist from another planet, for instance, that would swing it out toward the outer solar system. Conversely, if the sailcraft were in a high solar orbit and you wanted to bring it back toward the sun, you could angle the sail so that it was orbiting against the sun's pressure. That would slow down its orbit and thereby progressively lower its altitude (see diagram, p. 81).

Solarcraft have limitations, of course. Though solar sailing is all about acceleration—the sun's boost is almost imperceptible at first but keeps increasing over time—they are still far slower than conventional rockets. Depending in part on the size and weight of the sail, a trip from Earth orbit to the moon could take four to six months. According to another scenario, a journey to Mars would take two to three years, compared with a conventional rocket's flight of nine to 12 months. Furthermore, as a sail got farther from the sun, the pressure on it would diminish, so it would be of limited use in explorations of the outer solar system.

On the other hand, the technology's advantages—no fuel requirements, virtually unlimited maneuverability—would make solarcraft ideal for routine cargo hauling and for exploring hard-to-reach celestial bodies such as moons and asteroids. In the 1970s scientists at the Jet Propulsion Laboratory in Pasadena considered using a solar sailcraft to rendezvous with Comet Halley. The proposed sail, a "heliogyro" with helicopter-like blades made of aluminized plastic, would have taken about four years to haul a 1,800-pound scientific payload to the comet.

The mission offered the first opportunity for a probe to fly alongside a comet. Flying next to Halley would be tricky. To get a velocity boost, spacecraft are normally launched into orbit moving in the same direction as Earth, but Halley orbits in the opposite direction. A conventional craft would therefore have to completely reverse its orbit, a fuel-devouring maneuver no present craft is up to. A solar sail, on the other hand, requires no fuel to change orbit and velocity. Once in solar orbit, it could simply keep adjusting its inclination until its path was reversed. After two years of study, however, NASA rejected the idea in favor of a more familiar electric propulsion system; eventually, the entire Halley's mission was scrapped because of budget constraints.

As it happened, the demise of the project dovetailed with the founding of the World Space Foundation, a non-profit association of space enthusiasts, primarily from JPL and West Coast aerospace contractors, in search of do-


CHAD SLATTERY (2)

By day an engineer at JPL, Robert Staehle spends his spare time serving as the president of the WSF. Behind him is the group's sail-making apparatus; the prototype Mylar sail is wrapped around the large ring standing at center.

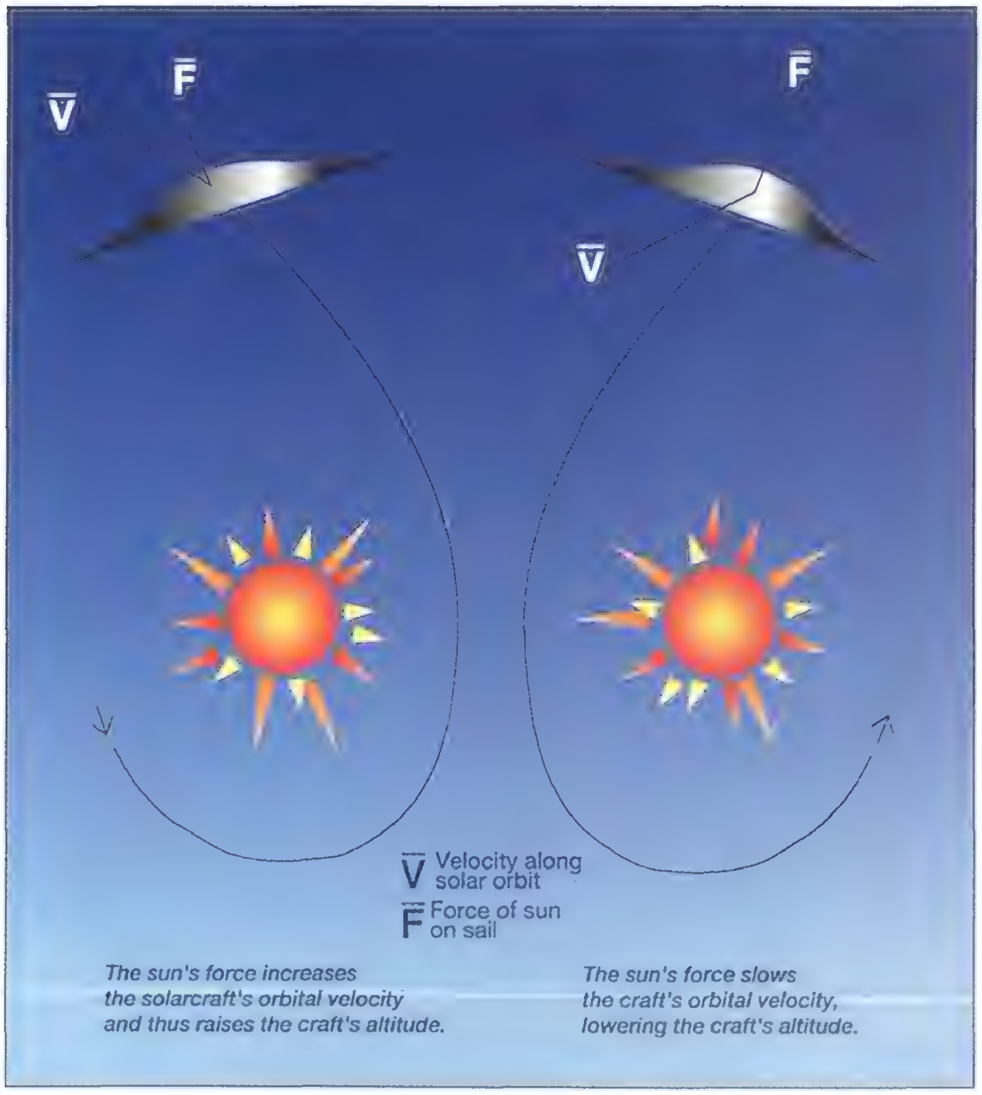
it-yourself space projects. The WSF thought a solar sail project was perfect, and the members set to work designing and building a sail of their own, unveiling a prototype square in 1981. Five years later the group was finalizing an agreement with NASA to deploy a larger version from the shuttle when the *Challenger* exploded, indefinitely suspending all agreements NASA had made under its collaborative Joint Endeavor program.

The WSF is headquartered in a one-story cinderblock strip of offices and garages in Pasadena. Unlocking a door and flicking on the lights, sail project director Emerson LaBombard reveals a dusty, raw concrete work area cluttered with boxes, tool trays, and amorphous piles covered with sheets of plastic. Situated along one wall is a long table outfitted with machine-tooled drums, alignment bars, and guy wires—a homemade sail making machine. In the back is a large ring around which is wrapped the prototype: 960 square yards of a thin plastic called Mylar.

"Most of this was done by a bunch of fellas just doing their thing on evenings and weekends," LaBombard says proudly. And yet the WSF's garage sail has gotten good reviews from no less an authority than the American Institute of Aeronautics and Astronautics, which in 1989 evaluated more than two dozen solar sail proposals as part of a competition staged by Klaus Heiss.

The idea for the competition dates back to early 1988, when Heiss had lunch with former Congressman James Symington. Symington had known Heiss from working on the House science and technology committee. When he left Congress, he became a lobbyist with the Washington law firm O'Connor & Hannan, which was doing pro bono work for the Columbus Quincentenary Jubilee Commission. During their lunch, Symington asked Heiss how the commission could stage a Columbus celebration in space. "That's easy," Heiss replied; "you put sails up and do a race to Mars."

The commission loved the idea, and it agreed to raise funding for the project if Heiss and Symington would handle the technical end. Heiss drew up



The sun's force increases the solarcraft's orbital velocity and thus raises the craft's altitude.

The sun's force slows the craft's orbital velocity, lowering the craft's altitude.

BASED ON JPL ART

rules for what was grandly dubbed the Columbus 500 Space Sail Cup: total solarcraft weight of no more than 500 kilograms (1,100 pounds); a minimal payload—a one-kilogram commemorative plaque; and no direct government funding. Then he put out a request for proposals through the AIAA.

Responses arrived from all corners of the globe. The variety was remarkable; sail designs came in squares, hexagons, parasols, and flexible disks. The AIAA pronounced six technically feasible, among them the one from the WSF. Heiss' favorite, from the Applied Physics Laboratory at Johns Hopkins, was a 560-foot disk weighing only 175 pounds—light enough to be launched on the little aircraft-deployed Pegasus. "That means I have broken free of this large space structure," Heiss states. "I don't need Titans, I don't need the shuttle. I can go back to where the space program started and launch it out of Wallops Island."

It's a grand dream, but the funding for it never materialized. The chairman of the Columbus commission, facing allegations of financial wrongdoing, was forced to resign, and as he went down the tubes, so did the race. Symington and Heiss tried to resurrect the idea, shopping it everywhere from NASA to the White House to the postmaster general's office. They trooped up and down the halls of Congress. They amassed enough letters of support to blaze a paper trail to Mars, including one from NASA offering tracking, telemetry, and other technical assistance in the event the race ever got off the ground.

But there was just no money. NASA might come up with funding, says Ivan Bekey, once sail technology is advanced enough to offer a clear-cut advantage over chemical propulsion—getting someplace in less time, or with twice the weight, or at half the cost. But that's a big leap from racing a two-pound payload to Mars. To use sunlight propulsion effectively, a spacecraft would need a huge sail, hundreds of yards across, made of extremely lightweight, durable material. "With today's materials," says Bekey, "a typical sail gives you an acceleration of three milli-Gs—.003 times the acceleration of the gravity of the Earth. To be useful, we need an order of magnitude more than that, say .03 or even .1. And to do that you need to cut the weight of the sail, which is to say the thickness of it, by a factor of ten." Then there are the engineering problems associated with packing such voluminous, flimsy material and getting it to unfold properly in orbit. Some scientists speculate that very large solar sails might have to be manufactured in space.

In the face of all these challenges, solar sailors around the world were cheered to see Vladimir Syromiatnikov hoist a symbolic banner in their behalf. Syromiatnikov piggybacked a 60-foot-diameter disk sail on a Progress resupply rocket bound for Russia's Mir space station. Early in the morning of February 4, 1993, after undocking from Mir, the Progress activated a spinning device to which the sail was attached. As the sail was spun it began to unfurl until it had become a hypnotic pinwheel, lustrous against the black void of space. Syromiatnikov's friends and colleagues, watching mission control screens in

The WSF's Emerson LaBombard is trying to find funding for a sail to race to the moon.

RICHARD NOWITZ

Klaus Heiss (left) and Vladimir Syromiatnikov (opposite, bottom) are teaming up for an eight-year solar sail test program. "It's a godsend!" declares Heiss.

Student volunteers, such as the two high schoolers at right, help construct test sails for the WSF. Once a working sail is made, it will be packed in a canister for launch (below; shown is a model).

KIM STEELE (2)

Moscow, broke into applause and cheers.

On a trip to the States six months later, Syromiatnikov was still beaming. Asked how the deployment went, the engineer broke into a gap-toothed smile, flashed the "A-OK" sign with his thumb and forefinger, and declared "Great!" He went on to elaborate: "We wanted first of all to refine the concept, and how such large structures may be deployed in orbit. Then, to prove that it might be controlled, because there was some doubt that it would be stable. It was even, I would say, unexpectedly stable." Stability was maintained by the assembly that attached the sail to the Progress and made it spin.

The most amazing thing was that Syromiatnikov got anything up at all, given the tenuous nature of the Russian space program recently. At first he was reluctant to say how he pulled it off. "I really don't know how we managed," he said cagily. "It must have been a magic trick." With a little prodding, he admitted that he had begged and borrowed parts and personnel from coworkers in the space program, then talked his bosses into letting him work on the sail in his spare time—a version of events confirmed by Heiss, who was invited to Moscow to watch the deployment. "What they did was systematically pilfer the shelves at Energia until they were so far along that their supervisors just said, 'All right, let's fly it,' " Heiss says.

Would that the U.S. space program were so flexible! "If we tried what we're doing inside the walls at JPL, there would be a tremendous hue and cry and JPL would get a big audit," complains WSF president Robert Staehle. Instead, the group worked out an agreement with two other sail groups, one French and one Japanese, to split the costs of a launch that would send all three craft on a race to the moon. Adding in the cost of constructing a racing sail, Staehle and LaBombard figure all they need to raise is a paltry $15 million.

Theirs is no amateur marketing effort. They got a Los Angeles public relations agency to put together a slick black binder promoting the project, complete with dazzling artwork and a shiny sample of sail material. They've also taken their act on the road, knocking on the doors of aerospace contractors, soft drink companies, Ted Turner, Bill Gates—anyone who might pay to see their name splashed across a solarcraft. But so far they've struck out.

"We've run into individuals who are interested, but they haven't been able to bring their companies along," says LaBombard. "The first time they run into some guy who says 'crackpot,' that's it."

"There must be something we're not doing that we ought to be," a frustrated Staehle says. "The problem is, we're a lot better engineers than we are fundraisers."

"A few months ago Rob was standing on the corner of a freeway with a sign that said 'Will Sail for Funds,' " jokes LaBombard.

"We haven't stooped that far," says

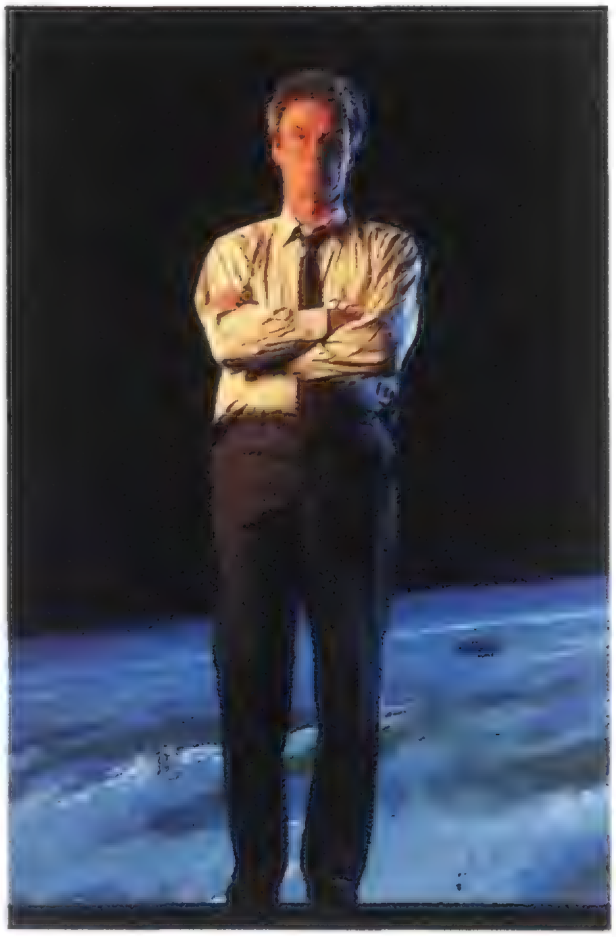
CHAD SLATTERY

Staehle. "We just haven't gotten to the exact right guy yet."

"Well, we've been a little snooty about cigarette and liquor companies," says LaBombard. "But we all have our price. And mine keeps going down."

NASA's Bekey, for one, hopes the WSF finds the money. "Many of us would love to see solar sails tested," he says, especially if it helps solve the difficulties of deploying such delicate, ultra-thin material.

Speaking of which, Klaus Heiss says he has found an Austrian group that can produce sail material as thin as one micron—a thousandth of a millimeter, 60 percent thinner than the fabric the WSF hopes to use. "And hence this research proposal," Heiss says, flourishing a draft agreement he drew up with Syromiatnikov for an eight-year, $126 million U.S.-Russian R&D program that would test sail prototypes out of Mir



and culminate in missions to Mars and the asteroid belt. Heiss and Symington, who continue to collaborate, plan to revisit all their Washington contacts and make a very simple pitch. "This really ought to be done," Heiss says flatly. "Because the public is getting bored by all the failures in the space program. This will be fantastic. It's a godsend!"

The longer Heiss thinks about it, the more uses he can come up with for solar sails. "There's something I call the wrapper defense," he says slyly. "Think about it—there's a lot of stuff up there right now. If I don't want a spy satellite to look at me, I go up and wrap it with a solar sail. And that's the end of one and a half billion dollars!"

He bursts into a wicked, gleeful laugh. "Let me tell you, sometimes I think they should lock me up, jail me."

Or book him passage on a slow boat to Mars.

What Makes It Wright?

Two reproductions of the Model B show that the same airplane can be very different.

by Howard Mansfield

Photographs by Cameron Davidson

When the Wright brothers' niece, Ivonette Wright, was 15 years old, she flew for the first time. It was 1911, and Orville took her up in a Wright Model B. In 1991, when Ivonette was 95, she made her last flight. It was also in a Model B, but those 80 years had brought some changes. Though this Model B had similar measurements, it was constructed of aviation steel, powered by a 205-horsepower Lycoming helicopter engine, controlled by ailerons, and more than twice as heavy. This Wright B was just like the original, "only newer," Ivonette said after the flight.

When an antique is revived in a version that is "only newer," it is bound to provoke discussion.

The builders of the new Model B had reinvented the Wright brothers, at the same time raising questions about how to balance the demand for historical accuracy with the need for flight safety. The builders opted for safety, and their changes reveal the risks and contradictions of trying to revisit the technological past. Some critics say their aircraft is not a Wright machine, and some, like Ivonette, say it is.

This Wright B was born as a Bicentennial dream in Dayton, Ohio. In 1974, Tom Sheetz, then chief of protocol for the aeronautical systems division at Wright Patterson Air Force Base, had envisioned a Wright Flyer leading the big Bicentennial parade down Main Street. He talked the idea up and caught the attention of Charles Dempsey, now retired from his position as chief of technical plans and programs at the Air Force's aerospace research lab. A B-24 pilot in World War II, Dempsey had always been "infatuated by the Wright brothers," and he couldn't understand why there wasn't a flying reproduction. "I'm at the birthplace of aviation and there ain't no airplane flying," he says.

The two men decided to build a Model B, the most practical of the early Wright aircraft. They thought their endeavor would last two years and require $15,000. Instead, it took seven years, the work of 600 volunteers, and materials, donations, and computer time worth about a million dollars.

Wright enthusiasts Charles Dempsey (below, left) and Tom Sheetz had long dreamed of a Wright reproduction flying the skies of Dayton, Ohio. In 1976 they started construction and spent the next six years building a Model B lookalike, which is now based at Dayton General Airport (left).

The town of Dayton greeted the project with enthusiasm. Dempsey was receiving 45 calls a day from people offering to volunteer. Everyone from Lieutenant General James A. Abrahamson (later head of the Strategic Defense Initiative program) to Cub Scouts came down to pop rivets into the airplane's wings. When Dempsey and Sheetz met with one local business leader, they were asked just one question: How much money do you want? But Dempsey and Sheetz wanted it to be a "people's plane," so they gathered $1, $2, and $5 donations. Eventually, they accepted bigger donations—including the hangar and the engine—from more than 200 corporations.

Once construction began in 1976, a core group of five volunteers worked closely for the next six years on the craft, developing a strong camaraderie. Since the group hoped to fly its Model B at Huffman Prairie, where the Wrights had tested their aircraft and run a flight school, they decided to conform to Air Force flight safety standards (Huffman Prairie is now part of Wright Patterson Air Force Base).

They started out by redesigning the entire Wright B. The

group consulted numerous engineers, had the design reviewed by the Air Force technical evaluation team, and received hundreds of hours of advice and computer time in designing the propellers and controls and choosing an airfoil. "We had to take a wooden plane and bring it to FAR [Federal Aviation Regulation] Part 23 standard, which is 6 G ultimate," says Dempsey, a big man with a southern drawl. "You're not going to have wood, friends. You're going to have chrome-molybdenum-steel tubes. That's what it says. And to keep the weight down you're going to have aluminum wing ribs. It also says that you're going to have aircraft steel cables. No piano wire.

"The real issue was not making a Wright B Flyer," he says. "The real issue was redesigning the original Wright B Flyer to FAR Part 23 standards without it looking different.

"And them old Georgia Tech boys," Dempsey says referring to himself, "are good at adjustment engineering. And that's what it was, baby, adjustment engineering." The adjustments included a modified chain drive, a gearbox, two Piper Cub J-3 gas tanks in the wings, FAA-approved propellers, full instrumentation, navigation lights, brakes, a larger rudder, heat-shrunk Ceconite wing covering, and small front wheels on the skids.

In answer to critics who say the plane has been "adjusted" beyond recognition, Dempsey says the new Wright B matches the original in the position of every strut and wire, and in every dimension. "It is a Wright machine," he says. "It takes off at the same airspeed, cruises same airspeed, stalls same airspeed, but it's got all those little adjustment engineering goodies."

The original Wright B is a linen handkerchief with ribs. When the wing warps and the ribs move, it is like a body taking a breath. The original Wrights are all skin and bones, with wires for connective tissue. They are animate in a way that modern aircraft are not.

Seeing this new steel Wright B is like seeing a slender track star in football gear. The landing gear can withstand 5 Gs. The wheels were built by a company that manufactures wheels for Indianapolis race cars. Dempsey built the lap belts and shoulder harnesses to withstand 15 Gs. He proudly recalls a compliment he received from a technical inspector: "You Georgia Tech guys make airplanes fly through brick walls."

Dempsey's group further modified their Model B by discarding the Wrights' airfoil. Consulting engineers at the Dayton section of the American Institute of Aeronautics and Astronautics selected the NACA 4412 airfoil, which has the same thickness as that of a PT-19 Army trainer. "I was happy as hell," says Dempsey. "I learned to fly on that airfoil."

Stability was Dempsey's chief concern. "The Pentagon said, 'If you are going to fly this thing at Wright Patterson, we've got news for you,' " says Dempsey. " 'You must come to neutral stability.' " So the group centered the engine and moved it slightly forward, positioned the pilot and passenger seats two feet forward of the wing, and added more than 100 pounds of lead to the landing struts in the nose.

Dempsey insists that the original Wright B was so out of balance that one person could not fly it; a copilot would have been needed for ballast. As proof, he points to a photograph taken by Orville that shows a Wright airplane sitting on the ground with its nose skids in the air. "That airplane is not in balance," says Dempsey. "That airplane will not take off." The Wright brothers, he says only half-jokingly, "were better photographers than they were engineers."

When Dempsey is told that many solo flights were made, such as Harry Atwood's record 1911 flight from St. Louis to New York, he says several hundred pounds of ballast must have been added. Wright historians, however, say that the Model B was easily flown with one

person and no ballast. Dempsey has no patience for those who contradict his beliefs, dismissing the challengers as ignorant "naysayers."

To keep its wings level during flight and to bank right or left for a controlled turn, the original Wright B used wing warping. With this early method of flight control, the pilot could independently alter each wing half's angle of attack by twisting the wing panels in opposite directions via wire cables. If one wing half is presented to the wind at a greater angle of attack than the other, it will generate more lift, cause that side of the airplane to rise, and result in the banking of the entire machine. The Wrights' wing could twist along its width without a loss of strength along its length. Even the fabric was sewn on in such a way that aided wing warping.

Instead of using wing warping for directional control, Dempsey's group substituted ailerons. Such an act is pure sacrilege to some in Dayton. It was, after all, the Wrights' arch-rival, Glenn Curtiss, who used ailerons, hinged panels mounted on both sides of the airplane that could be raised or lowered, thus creating a lift differential on either side of the aircraft.

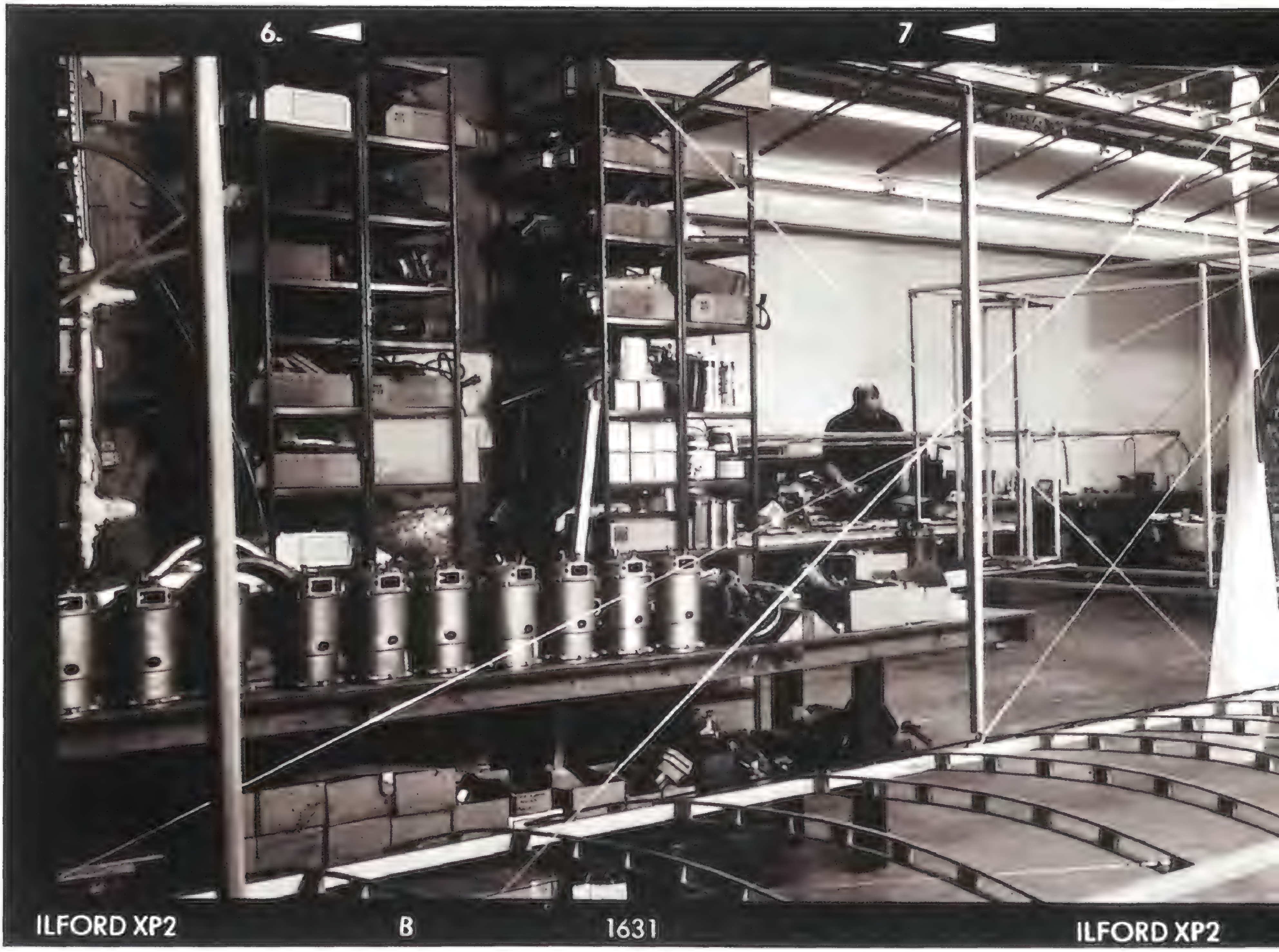
Aside from using a metal construction in place of a wooden one, this was the biggest departure Dempsey's group made from the original. Dempsey defends his decision by pointing out that a Model B at the Air Force Museum in Dayton also has ailerons. But this airplane didn't start out that way; when it came out of the Wright factory, it was built for wing warping. It changed ownership over the years, and at some point in its history ailerons were added. The Air Force Museum's modified B was the sole model for Dempsey's airplane. (The only other surviving Wright B is at the Franklin Institute in Philadelphia.)

In promotional material, Dempsey's aircraft is wisely billed as a "look-a-like," not a reproduction. At the project's start, group members carefully measured the Air Force B and had senior high school drafting classes convert their 40 pages of measurements into drawings. Their Model B is even painted to look like the Air Force machine, with battleship-gray struts and dark brown wings.

From April to October it flies a demonstration every Saturday, weather permitting, at Dayton General Airport. Each

John Warlick (opposite), one of the Model B's three pilots, often flies in a second lieutenant's uniform from the Wright-era Army Signal Corps.

Chief mechanic Harold Edinger (below, at left) and pilot Donald Stroud are two members of the all-volunteer staff that keeps the Model B in pristine condition.



year it makes an appearance at the Dayton International Airshow, offering the audience a close look: it flies at an altitude of 100 feet and a top speed of 55 mph. The Model B has also flown at four other airshows, including the one at Tempelhof Air Force Base in Berlin, where the Wrights flew in 1909. So far, Dempsey's airplane has given rides to over 600 people; for a donation of $125, you can fly the length of the runway at an altitude of 50 to 75 feet and receive a certificate of flight, as well as your choice of a Wright B tie or scarf.

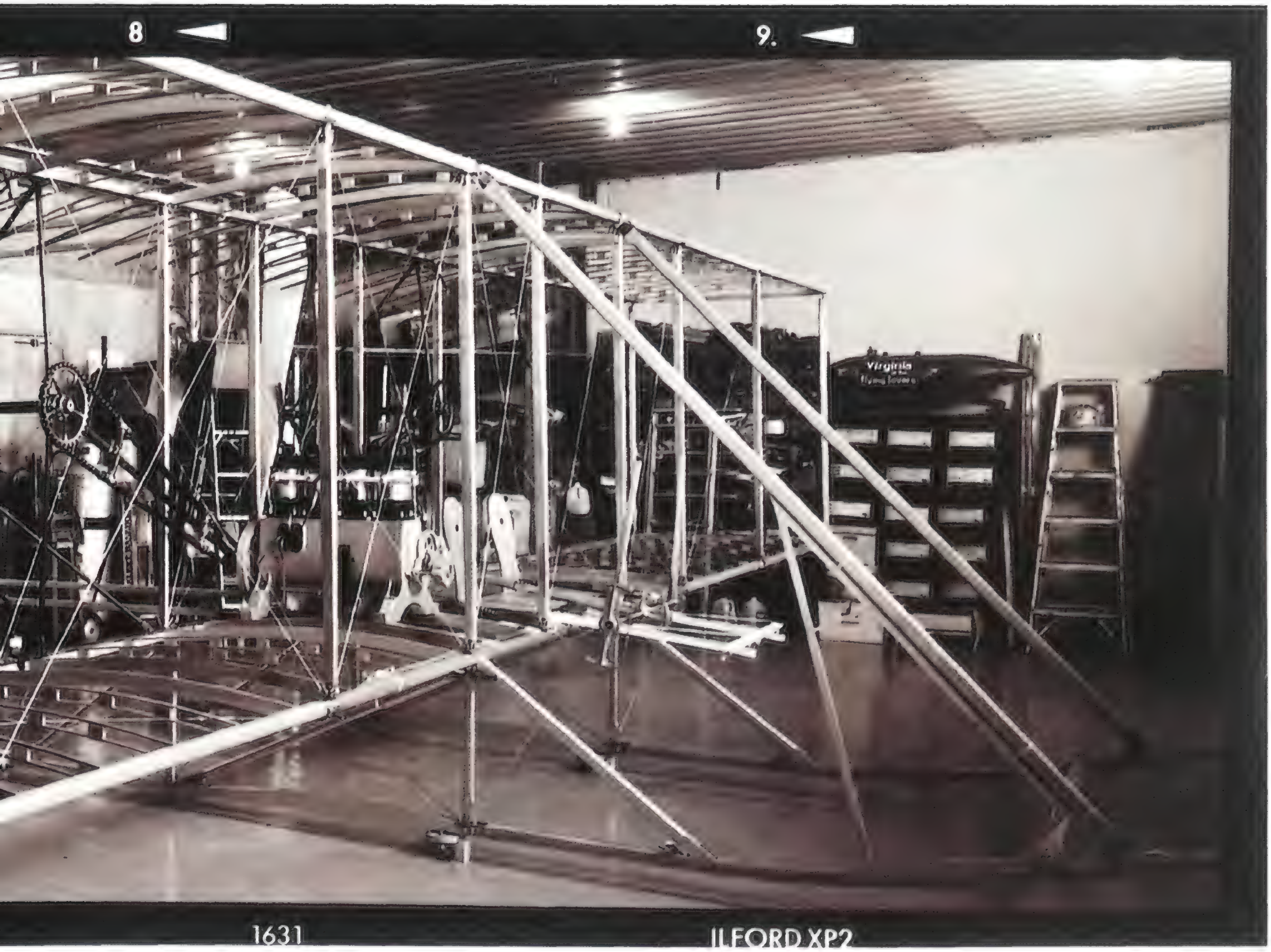
Flying this new version of the Wright B is "like driving an old worn-out tractor across a plowed field," says John Warlick, a retired Navy pilot and one of three pilots who fly the Model B. He had to make two emergency landings early on, once when the chain broke 300 feet from the ground and a second time when the propeller shaft broke. Each time he landed without mishap. (Dempsey, 69, had always planned on flying his creation, but he lost his medical certificate in 1983 due to health problems.)

Despite the Model B's popularity at airshows, it has stirred controversy. Although Dempsey's group built the Wright B to Air Force standards, the Air Force refused to allow them to base it at Huffman Prairie. "We wanted to be at Huffman Prairie," says a glum Dempsey. "We tried three times to get in at Huffman Prairie. The base commander at that time wasn't too happy about this thing." Unfortunately, the group's good intentions of building a "people's plane" to lead the parade down Main Street hadn't made their airplane immune to the whims of military politics.

According to Dempsey, his group didn't base the airplane at their second choice, the Air Force Museum, because they couldn't afford to build a hangar that would meet the Air Force's civil engineering requirements for a building open to the public on military land. The Wright B finally found a home some 24 miles from Huffman Prairie, at the Dayton General Airport in Miamisburg.

Experts on the Wright brothers admire the spirit of the Dayton group but express some reservations. Tom Crouch, chairman of the National Air and Space Museum's aeronautics department, author of the Wright biography *The Bishop's Boys,* and a Dayton native, flew in the airplane and says, "I got to ride with my feet dangling over the wing of a Wright airplane, and from that point of view it's a really neat thing to do. There's nothing else flying that comes to mind that allows you to kind of taste that sort of sensation." But he says cautiously, "the notion of building the 'all-metal Model B' has some limitations."

Peter Jakab, an aeronautics curator at the National Air and Space Museum and author of *Visions of a Flying Machine: The Wright Brothers and the Process of Invention,* says: "What the guys did in Dayton is great, but it's barely a Model B."



The delicacy of the Wrights' wooden construction has been faithfully copied in Ken Hyde's non-flying Model B, bound for the U.S. Army Aviation Museum at Fort Rucker, Alabama.

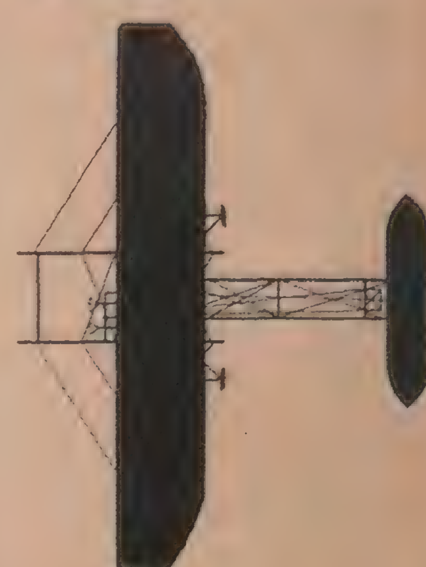
Rick Young, a Wright enthusiast and restaurateur who has built and flown several Wright kites and gliders, is less circumspect. "The Wright brothers would be horrified at it. That's my feeling," he says. "[Dempsey's group] built a machine like a carnival ride to be able to go out and fly people around. It's not even a Wright brothers airplane—doesn't have wing warping, it's made of metal."

What the Dayton group missed, says Young, was the thrill of reaching a deeper understanding of the Wrights. When you build an accurate reproduction, "you begin to seek answers for questions that wouldn't even occur to a historian: how a particular piece was fabricated or how it was assembled. Or what material they used or why. When you go to build something you have to answer all of these questions. And then there's all those 'ah-hahs' that happen: *Oh,* that's *why they did that. Now I see.*"

When asked how an antique aircraft should be revived, these Wright experts all point to the work of Ken Hyde, an airline pilot and experienced restorer who is building a reproduction of Signal Corps #3—a Wright Model B—for the

The Wright Model B

All wing and no fuselage, the Model B left its pilot and passenger exposed to the wind. Fortunately, the aircraft's top speed was only 55 mph. The 1,250-pound biplane was powered by a 35-hp, four-cylinder engine designed by Orville and Wilbur.



By painstakingly reproducing the Wrights' technology, Hyde hopes to experience flight the way Wilbur and Orville did.

Greg Cone (opposite), one of Hyde's two assistants, has searched doggedly for clues that could shed light on how the Model B was put together.

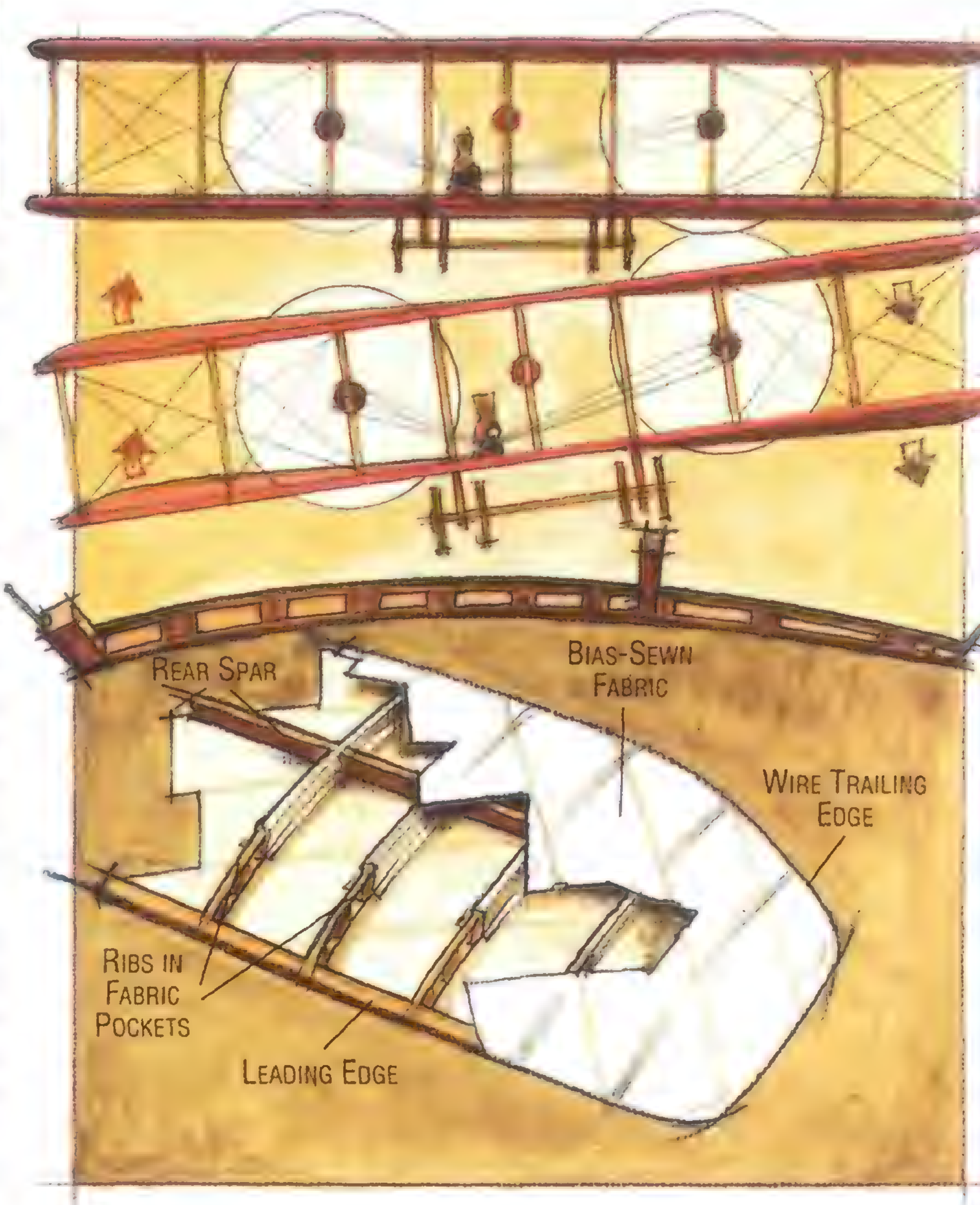
U.S. Army Aviation Museum at Fort Rucker, Alabama. At the same time, he's building an almost exact flying reproduction of his own, which will be powered by a copy of the original engine. "The Wright brothers didn't build stuff as nice as he does," says Young. "He has set a standard. Ken's work is meticulous."

Hyde works at his own hangar and airstrip outside Warrenton, Virginia, not far from where he grew up. He built the hangar before he built his house, something his wife still reminds him about. The hangar has the air of a museum restoration department. In the office, Hyde's desk faces a wall covered with yellow Post-it notes, a testimony to his persistence in tracking down the smallest of details. Hyde and his assistants, Greg Cone and Andrew King, have assembled an encyclopedic knowledge of the Wright B and the Wrights' thinking and methods. They've had to: the Wrights were secretive. They left no blueprints of the Model B.

Hanging on a wall is the broken wing of a Model B that last flew in Iowa in 1916. The bracing wires that hang all about it give it the look of an abstract mobile. The wing has been an important source for studying the original fittings. Says Cone: "We measure anything we can get our hands on and record it."

Throughout the workshop are five thick loose-leaf binders containing letters, documentation, and photographs of the Wright factory. By closely studying these photos, which show piles of wings and chain guards, the group has discovered how various parts were fabricated. "There are clues in all of it," says Cone. He points to a 1910 factory inventory. "See, it says ash skids," he says. "You see an airplane at a museum, you can't very well take out your pocket knife and carve into it [to see what it's made of]." They also refer to their extensive flat files, which hold almost every available drawing of Wright machines from around the world, including a remarkable 1909 notebook from a British manufacturer and drawings made under the Wrights' guidance that show the measurements of the 1909 Flyer.

"There's so many secrets in there," says Cone, admiring one of the drawings. He points out that threaded through an opening at the bottom of one of the aircraft's 18 vertical struts is a metal hook that attaches the strut to the wing. "Without the drawings you wouldn't know how [the hook] went there," he says. "The whole plane is just hinged together. That's



why they fell into a heap when they crashed."

People think that Wright airplanes are just big kites with an engine, Cone says, but they're missing the heart of the Wrights' technology, all the small details that allowed the wing to flex in flight, such as the grain on the spruce used to make the wing ribs. Since the Wrights wanted to keep their aircraft as light as possible, they made only the center-section ribs out of solid wood. For the remaining ribs they used two thin strips of spruce—an upper strip and a lower strip—separated by blocks of wood at six-inch intervals. The spruce strips, some six feet in length, are a half-inch wide and a quarter-inch deep. Common practice would tell you to cut the wood so that the vertical grain is visible on the wider side, which in this case would make for a stronger rib. "When we got these old wings we were looking at them, and they put the grain on the quarter-inch side," says Hyde, whose reserved manner is a match for the Wright brothers'. "We decided they made a mistake. So we said, 'Okay, we're going to put the grain like you're supposed to.'

"In the middle of the night I woke up," he continues. "You know there's got to be some reason why they did that. I know they didn't have a lot of previous aviation knowledge, but there's a reason they did this." So Hyde's team tested the ribs with the grain running both ways by hanging weights off of different strips. Using the original configuration, the rib flexes nearly two inches more—essential since wing warping requires much of the wing to flex.

To further increase flexibility, each rib is fastened to the wing at only one place—the leading edge. What holds the rib in place is a pocket sewn onto the interior of the wing's

The Wright Way

To begin a controlled turn, the Wright brothers used wing warping (left). At top, the Model B is in level flight. Below it, the aircraft has begun a bank to its right. The leading edges of the biplane wing remain stable but the trailing edge of the left wing twists down, generating more lift and causing that side of the aircraft to rise. Simultaneously, the right wing's trailing edge twists upward, causing that side of the aircraft to lower. If the banking motion is sustained, the aircraft will complete a full turn to the right.

The Wright wing was like no other. To keep the wing light, most of the ribs were constructed not of solid wood but of upper and lower strips separated by blocks. The ribs, though held in place by fabric pockets, are fastened to the wing only at the leading edge, allowing them to flex without breaking. All wing elements, including the bias-sewn fabric, were designed to move in concert during a wing warp.

muslin covering. "Now [the wing] doesn't hold up well over long periods of time," says Hyde. But the wing's achievement lies in its lightness and in the control it allows. "If you go out and pick up that wing," says Hyde, "I would daresay anybody, even in composite material today, would have a very difficult time matching the weight for the square footage of that wing." And remember, he says, this is only a third-generation airplane. Hyde sees the Wrights as geniuses of fabrication.

Hyde and Cone stand looking at the elegant work of a wing under construction. "And it all gets covered up," says Cone. "That's why people look at it and say there's nothing to it."

It hasn't always been easy for Hyde to find airplane parts similar to the ones Wilbur and Orville employed. For wingtips, the brothers used buggy bows, lengths of ash softened by steam and bent to form the upper skeleton of a cloth-covered, horse-drawn carriage. Fortunately, Hyde was able to find an Amish craftsman still making them. The Wrights also specified that "Dairy Tin" be used to fasten the ribs to the leading edge. "What is it? Nobody knows," says Cone. Whatever it is, it doesn't rust—not even the edges. On the Iowa wing the nails have rusted but not the tin. Hyde has a metallurgist studying a sample.

Hyde and his assistants have examined an original Wright strut with the finish still on it, and they intend to duplicate this finish on their own aircraft. Orville and Wilbur's Model B was a silver ghost: all of the fittings were nickel-plated and all of the woodwork was dusted with aluminum powder over a wet varnish. As Hyde sees it, going to the expense of painting the airplane was the Wrights' version of stealth technology. "The film at that time was all silver-backed," says Hyde. "If you paint something aluminum it just kind of blends right into the negatives. You couldn't tell what was ash and what was spruce. So if you're going to just copy their airplane—and there were a lot of people doing that—from their photographs, you wouldn't be able to tell. It just disappears. Very effective."

Hyde has made some modifications to the reproduction he intends to fly, but they too are hidden: he has employed a higher grade of aviation steel for the hardware, put shear pins on the prop shaft, and used bolts in place of wood screws, installing thin plywood pads under the bolt heads. To the eye, it will appear exactly the same.

Andrew King examines the center section of Hyde's lower wing, which employs solid wood ribs to support the weight of the pilot, passenger, engine, and fuel tank (above).

The Model B's metal parts, including the engine's iron cylinders and aluminum crankcase (opposite, top) are cast at a foundry, but Hyde does the machining himself (right).

Dempsey thinks Hyde would be foolish to fly his Model B using the original controls. "It's different—it's going to be like patting your head and rubbing your tummy, all at the same time," acknowledges Hyde, who has flown with American Airlines for 28 years. He is considering making a flight simulator much like that used by the Wrights to train their students.

By the time he flies, he'll be no stranger to his airplane. Detail by detail, Hyde has gained insight into the Wrights. "It's been a very strong history lesson," he says, a lesson he would have missed had he updated everything. "And then you don't have a Wright airplane. I think it's going to be fascinating to hear a four-cylinder vertical Wright engine run. We've never heard one run.

"Every airplane, every piece of machinery smells or looks different," he says. "When you find an old car that hasn't been touched, you get into it—it smells different, it looks different. And the reason it's that way is because they've used horsehair, they've used certain kinds of leathers, and they've used certain kinds of glues. Take that car and you put it all together with plastic and T-88 epoxy adhesive, it's not going to smell and look the same.

"That's kind of the way I think it is with antique restoration," he says. "You need to try and get as close [as you can] to the materials that went into it. And that's what we're trying to do with the Wright airplane. I think that comes from doing the paint the way they did, doing the gluing they way they did it, putting horsehair in [the seats] the way they did it, putting the same fabric on." Each piece by itself may not mean a whole lot, says Hyde. But "when you put it together: Wham. It's 1910."

A Tale of Two Astronauts


NASA

Mercury astronauts on a desert survival exercise wear costumes made from parachutes.

Moon Shot: The Inside Story of America's Race to the Moon *by Alan Shepard and Deke Slayton with Jay Barbree and Howard Benedict. Turner Publishing, 1994. 383 pp., b&w photos, $21.95 (hardcover).*

Although I can't prove it, I will eat my computer, mouse and all, if either Alan Shepard or Deke Slayton contributed so much as a comma to this book and if the real authors are not Jay Barbree and Howard Benedict (not the "by's" on the jacket; the "with's"). Both are veteran space reporters, for NBC and the Associated Press, respectively. The book has the breathless style of an AP news flash and the stentorian drama of an NBC news special. The characters are somewhat stereotypical and two-dimensional; the astronauts apparently did not convey much of their personalities or perceptions to their authors. But then Shepard and Slayton clearly are men of action, not words.

That said, the book is a well-crafted and often gripping account of the Mercury, Gemini, Apollo, and Apollo-Soyuz programs, with the intertwining lives of the two astronauts as a frame; the prose is hard-hitting and vivid, verging sometimes on the apocalyptic. But all of this adds to a sort of mythic sense, American style—and the early days of our space program, Mercury, Gemini, and Apollo, are by now the stuff of legend.

Slayton and Shepard, like Castor and Pollux—the original Gemini—were well paired (Slayton died last year). Close friends, their careers had a symmetry well known in the epics of space: they were Mercury astronauts together, they were grounded for medical reasons, they spent many years sulking (like Achilles) in the astronaut office while enthusiastically helping their fellow astronauts ride to orbit or beyond (a fact that allows the authors to survey the entire manned space program before the shuttle), and finally both were triumphantly restored to flight status. Shepard, our first astronaut in space, got to go to the moon, and Slayton flew aboard Apollo-Soyuz.

The book is filled with excellent narratives and marvelous moments. The authors deliver good descriptions of the Russian space program—the first spacewalk, by Alexei Leonov; the final orbits, before his death, of Vladimir Komarov; the Soviets' abortive moon program, replete with spectacular rocket explosions. And they write vividly of Americans in space, particularly Shepard's two flights. His descent to the lunar surface aboard the Apollo 14 module—including an abort signal that was overridden and a last-second save of the landing radar—is a cliffhanger. Of the two astronauts, Slayton seems to come the more alive and to have revealed more about himself to the authors, particularly in a section about life at Star City while training for Apollo-Soyuz.

Moon Shot is a fast-paced book, written with something of the pounding intensity of a rocket ride through max Q. It is a good read, if not because it reveals the subtle nuances of space travel then because it is an epic tale vigorously told.

—Henry S.F. Cooper Jr. covered the Apollo landings for the New Yorker.

CURATOR'S CHOICE

Vietnam: The Helicopter War *by Philip D. Chinnery. Naval Institute Press, 1991. 189 pp., b&w and color photos, $36.95 (hardcover).*

This operational history ranks among the best books written about the role of the helicopter in the Vietnam war. Brimming with revealing photographs, riveting personal anecdotes, and fascinating appendices, this thoroughly researched book is an excellent account of a milestone in the history of helicopter warfare.

—Russell Lee is a curator in the aeronautics department of the National Air and Space Museum.

THE ASTRONAUT BOOK CLUB

In 1962 the Mercury astronauts contributed to a book called *We Seven.* Since then the list of astronaut-authors has grown considerably:

Memoir/autobiography
Buzz Aldrin *Return to Earth; Men From Earth.*
Joseph P. Allen *Entering Space.*
Neil Armstrong, Michael Collins, and Buzz Aldrin *First on the Moon.*
Frank Borman *Countdown.*
Michael Collins *Carrying the Fire; Liftoff;* and *Mission to Mars.*
Walter Cunningham *The All-American Boys.*
Charles Duke *Moonwalk.*
Virgil Grissom *Gemini.*
Jeffrey A. Hoffman *An Astronaut's Diary.*
James Irwin *To Rule the Night.*
Brian O'Leary *The Making of an Ex-Astronaut; Exploring Inner and Outer Space; The Second Coming of Science.*
William Pogue *How Do You Go to the Bathroom in Space?; Astronaut Primer.*
Walter Schirra *Schirra's Space.*

Fiction
Scott Carpenter *The Steel Albatross.*
Edward Gibson *Reach; In the Wrong Hands.*
Mike Mullane *Red Sky.*
Brian O'Leary *Spaceship Titanic.*
William Pogue *The Trikon Deception.*

Children's books
Alan Bean *My Life as an Astronaut.*
Michael Collins *Flying to the Moon and Other Strange Places.*
Sally Ride *To Space and Back; Voyager; The Third Planet.*
Alfred Worden *A Flight to the Moon.*

Textbooks
Owen Garriott *Introduction to Ionospheric Physics.*
Edward Gibson *The Quiet Sun.*
Edgar Mitchell *Psychic Exploration.*
Thomas Stafford *The Pilot's Handbook for Performance Flight Testing; The Aerodynamics Handbook for Performance Flight Testing.*

Poems
Alfred Worden *Hello, Earth: Greetings from* Endeavour.

Miscellaneous
John Glenn *P.S., We Listened to Your Heartbeat* (letters Glenn received).

Forthcoming
Michael Collins *Space Machine.*
James Lovell *Lost Moon.*

Wings of the Morning *by Orestes Lorenzo. St. Martin's Press, 1994. 346 pp., b&w photos, $22.95 (hardcover).*

Wings of the Morning is an aviation tale, to be sure, but sandwiched in between Orestes Lorenzo's air adventures is the education of a peasant boy. It is a beautiful, classic story about the loss of innocence, the rise of anger, the rediscovery of a hidden self that cannot be erased by totalitarianism, and finally the breaking free of tremendous bonds and coming home.

The story is made more poignant by the fact that Lorenzo flew away to this freedom, away and back. On March 20, 1991, Lorenzo stole one of Fidel Castro's MiG-23BN fighter-bombers and flew to Boca Chica Naval Air Base in Florida, seeking political asylum. He landed there before the astonished eyes of Naval flight controllers. Making the story more amazing was the fact that he flew a Cessna back to Cuba, landed on a road, picked up his family, and brought them to his new home in the United States (see "One Hundred Minutes to Freedom," December 1993/January 1994).

But the story in between those two astounding feats is a touching tale of who Orestes Lorenzo is, how he became a fighter pilot for the Cuban air force, how he was indoctrinated into a modern totalitarian government's military culture, and how the slow but implacable growth of humanity and feeling and comprehension within his heart and mind finally became overwhelming and undeniable. Lorenzo was stationed in Angola for a time, and one night a fellow pilot at a drinking party saw a Soviet colonel shoot an Angolan civil engineer point blank in the head over a minor political argument. The next day the Russians spirited the colonel out of the country to avoid a scandal. It was like one of the chilling disappearances in George Orwell's *1984*. In fact, Lorenzo reminds one of *1984*'s Winston Smith: a moral man who wanders through a world of raw, corrupted power. The realities encountered seem all the more savage because of Lorenzo's increasing sense of betrayal.

As the cracks appear in his indoctrination, as Lorenzo begins to suspect his leaders of being false, we discover the truth with him. Lorenzo is not a professional writer, but his passion and conviction are so great that they sear through to the surface and make the book even more compelling. There is the Cuban doctor who is sending home U.N. shipments of clothing intended for Angolan refugees. There is the Cuban intelligence officer who asks Lorenzo to seduce the wife of Lorenzo's friend in order to spy on him. And there are beautiful and wrenching moments, as when the three-year-old son of a pilot mistakes Lorenzo for his dead father and runs up to him, calling "Daddy, daddy!"

In the end, Lorenzo's flight to retrieve his family becomes a kind of universal flight for justice and logic in the face of a chaotic, duplicitous, and voracious power. And even those of us who are outside his predicament, who understand how one-sided his view of Russia is, can appreciate the tremendous struggle he endured to escape the nightmare of his military life in Cuba and bring back his family intact.

—Laurence Gonzales is the author of a new collection of essays called The Hero's Apprentice, *which will be published this fall by the University of Arkansas Press.*

FOR THE KIDS

Fly! A Brief History of Flight Illustrated by Barry Moser *(HarperCollins, 1993, 48 pp., $16.00, hardcover)* is a chronicle of 16 significant events in the history of flight, portrayed in watercolor images of famous aviators and their aircraft.

Carrier Warfare in the Pacific: An Oral History Collection *edited by E.T. Wooldridge (foreword by John B. Connally). Smithsonian Institution Press, 1993. 309 pp., b&w photos, $24.95 (hardcover).*

In World War II, the U.S. Navy's main airfields were afloat, requiring a team effort among aircraft and aircraft carrier designers and builders, tacticians, carrier admirals and captains, ships' companies, pilots, and air crews. This superbly balanced collection of 20 interviews representing all contingents is therefore a welcome addition to the literature. It is the work of a retired naval aviator, currently a chair holder at the National Air and Space Museum.

The focus is on the high drama of battles between airplanes and between airplanes and ships, all set in historical context by the editor. Jimmy Thach credits Butch O'Hare and Jimmy Flatley for helping him develop the defensive fighter weave they used so effectively at

Midway and elsewhere during 1942-43. David McCampbell, the Navy's leading ace with 34 kills, details tactical changes responsible for his successes in 1944 with the F6F Hellcat. McCampbell succeeded in spite of the fact that the training his squadron received was inferior to the dive-bombers', according to Kent Lee, an ensign in both squadrons on the *Essex* and later a vice admiral. Also, McCampbell's memory of the Leyte air battles is corrected in the excellent foreword by his fighter director, John B. Connally, later Secretary of the Navy.

The Hellcat is recalled in valiant terms. Good as the F6F was, Herb Riley at the Bureau of Aeronautics had to force Roy Grumman—"Oh, it broke his heart"—to halt Hellcat production at one point and instead produce spare parts vitally needed by operating units. "Jig Dog" Ramage led his SBD Dauntless squadron from the *Enterprise* against the Japanese fleet in the Battle of the Philippine Sea so successfully that the airplane outclassed its replacement, the SB2C Helldiver, but production schedules had already made this carrier action the SBD's last. Torpedo-bomber pilot Bill Martin gives the personal touch to his account of his key role in developing night doctrine, which culminated in his command of the first night carrier air group during 1945.

Aerial bombings, torpedoing, and kamikaze suicide attacks against carriers are superbly recaptured by several veterans, as is routine life on the flattops, especially by two enlisted men. Roger Bond reveals that the pre-war *Saratoga* retained its hammocks and buckets instead of being refitted with the bunks and wash basins of the new ships, while ingenious swabs built their own stills. And Chief Yeoman Cecil King hardly left the second *Hornet* for a year and a half but "enjoyed every damn day" of it.

Assessments of the leading carrier admirals differ widely. Unfortunately, Thach defends John S. McCain, for whom he was the principal staff planner, by denigrating Marc A. Mitscher. But the latter's chief of staff, Arleigh A. Burke, regarded Mitscher as "probably the greatest air combat commander that the world had ever known to that time," a view shared by Admiral Gerald F. Bogan in the book and by most naval aviators and historians. Admiral Jocko Clark also earns high marks from other contributors.

That is the beauty of oral histories like this one—recalling how people interacted with one another and responded to the heat of battle.

—Clark G. Reynolds is professor of history at the University of Charleston, South Carolina, and 1993 recipient of the Admiral Arthur W. Radford Award for Excellence in Naval Aviation History and Literature.

SECOND GLANCES

You Want to Build and Fly a WHAT? or...How I Learned to Fly, Built a WWI Replica, and Stayed Married *by Dick Starks. Butterfield Press, 1992. 249 pp., $12.95 (paperback).*

Picture being the tower controller at a Midwestern air base when a pilot calls in from 15 miles out and says he's going to land. You tell him to take runway one-eight and call back when he's on a two-mile leg. But after five minutes you haven't heard from him so you call to see what's wrong. The pilot says nothing's wrong, he's still 12 miles out. You ask what he's flying, and he answers "a warbird."

And he's right. It's a Nieuport 11, vintage 1916, which pilot Dick Starks built himself. Starks is a math teacher blessed with a glorious sense of adventure, a bunch of clever mechanical friends and helpers—including his ex-aeronautical engineer dad—and a wife who manages to put up with the whole business. He tells his story well in this little book. Cartoons illustrate it, and so they should, for it's a cartoon story of falling in love with airplanes and actually building one. His Nieuport was a little scout fondly called *bébé* by the French and bravely flown by Americans in the Lafayette Escadrille. Starks' story of flying the kit craft—powered by a VW engine—to Oshkosh neatly captures the problems of the old and slow days. He follows the concrete beam—a superhighway—and with a head wind, the traffic on the ground storms past him at about twice his speed.

So here are the confessions of a flying nut, zestfully told. Read it and hear a small voice in a corner of your mind murmuring something like "Why don't I try this?"

—Edwards Park is a contributing editor of Air and Space/Smithsonian.

CREDITS

Mr. Marseille. Charles Lunsford is a Cadillac salesman in Albuquerque.

War Games. A B-17 crew chief and flight engineer during World War II, Ben Warner now confines his flying to commercial airlines.

"Did He Say Five Hundred Feet?" Daniel Ford is the author of *Flying Tigers: Claire Chennault and the American Volunteer Group*. He wrote "Gentlemen, I Give You the Whittle Engine" in the October/November 1992 issue of *Air & Space/Smithsonian.*

Further Reading: *Marauder Men: An Account of the Martin B-26 Marauder*, John O. Moench, Malia Enterprises, Inc., 1989.

Apollo's Geology Lesson. Billy Goodman's article "The Planet Hunters" (*Air & Space/Smithsonian*, October/November 1992) won the American Institute of Physics science writing award for physics and astronomy.

Further reading: *To a Rocky Moon: A Geologist's History of Lunar Exploration*, Don E. Wilhelms, University of Arizona Press, 1993.

When We Last Saw Our Heroes... Andrew Chaikin is a frequent contributor and the author of *A Man on the Moon: The Voyages of the Apollo Astronauts.*

Birds of a Feather. Karen Jensen is an associate editor at *Air & Space/Smithsonian.*

The Tip of the Sword. Tom Harpole wrote "The Smokejumpers" for the August/September 1993 issue. He lives in Avon, Montana.

We'd Rather Be Solar Sailing. Frank Kuznik wrote "Blundersat" for the December 1993/January 1994 issue.

Further reading: *Starsailing: Solar Sails and Interstellar Travel*, Louis Friedman, John Wiley & Sons, 1988.

What Makes It Wright? Howard Mansfield is the author of *In the Memory House*, a book on the cultural history of New England.

Further reading: *Visions of a Flying Machine: The Wright Brothers and the Process of Invention*, Peter L. Jakab, Smithsonian Institution Press, 1990.

Home of the Yellow, White, and Blue. Austin, Texas freelancer Damond Benningfield writes and produces the syndicated radio program "Star Date."

CALENDAR

June 4 & 5
Twentieth Annual London International Air Show. Vintage and current military aircraft. London, Ontario Airport, Canada, (519) 659-3298.

June 5
Dawn Patrol Fly-In. Owosso Community Airport, Owosso, MI, (517) 723-4166.

June 10 & 11
27th Annual Pilot Proficiency Air Derby. Hot Springs, AR, (501) 753-4814.

44th Annual Moonlite Fly-In and Airshow. Antique aircraft, warbirds, homebuilts. Porterville Municipal Airport, Porterville, CA, (209) 535-4510.

June 10–12
High on Kalamazoo Air Show. Aerobatic performances, warbirds, U.S. Navy Leap Frog Parachute Team, static displays. Kalamazoo, MI, (616) 381-1692.

June 22–25
18th Annual Air Race Classic. A 2,428-mile air race for women pilots. Cahokia, IL, (512) 289-1101.

June 25 & 26
Potomac '94 Experimental Aircraft Association. Chapter 36 Fly-In. Potomac Airpark, Berkeley Springs, WV, (717) 294-3221.

July 2–4
Port Clinton Gathering of Eagles Air Show & Fly-In. Liberty Air Museum, Garfield Heights, OH, (216) 441-0661.

July 4
Fifth Annual Rockport-Fulton Fourth of July Airshow. Antique, homebuilt and military aircraft on static display. Aerobatic and military flybys. Aransas County Airport, Rockport, TX, (800) 242-0071.

July 20–24
1994 United States Air and Trade Show. Airshow July 23-24: U.S. Air Force Thunderbirds, flight demonstrations, and static displays. Dayton International Airport, Dayton, OH, (513) 898-5901.

July 23
National Aviation Hall of Fame Enshrinement Ceremony. Dayton Convention Center, Dayton, OH, (513) 226-0800.

July 28–August 3
Oshkosh '94. "Salute to Apollo" to commemorate the 25th anniversary of Apollo 11. Wittman Regional Airport, Oshkosh, WI, (414) 426-4800.

"The Satellite Sky" Update/42

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

New launches

90 to 300 MILES

Cosmos 2274
3-17-94 PL

Progress M-22
3-22-94 TT

300 to 630 MILES

Koronas 1
3-2-94 PL

6,200 to 13,700 MILES

GPS-24
3-10-94 CAC

21,750 to 22,370 MILES

Milstar 1
2-7-94 CAC

Galaxy 1-R
2-19-94 CAC

Deletion

90 to 300 MILES

Progress M-21
down 3-23-94

Launched but not in orbit

90 to 300 MILES

STS-62 U.S. research	3-4-94	down 3-18-94
STS-59 U.S. research	4-9-94	down 4-20-94

DATA: SAUNDERS KRAMER

FORECAST

In the Wings...

Hollywood's Air Force. When airplanes star in action adventure movies, directors sometimes use scale model stand-ins or special effects trickery. But in some scenes, like several in this summer's *Clear and Present Danger*, there's no substitute for a stunt pilot.

Destiny in Space. On their successful mission to repair the Hubble Space Telescope, the shuttle astronauts had an IMAX camera along. If you're lucky enough to see the footage, you'll be glad they did.

The Airship Hangar at the Top of the World. An aviation archeologist investigates the Arctic camp abandoned in 1909 by U.S. adventurer Walter Wellman and finds understanding about the human need to explore.

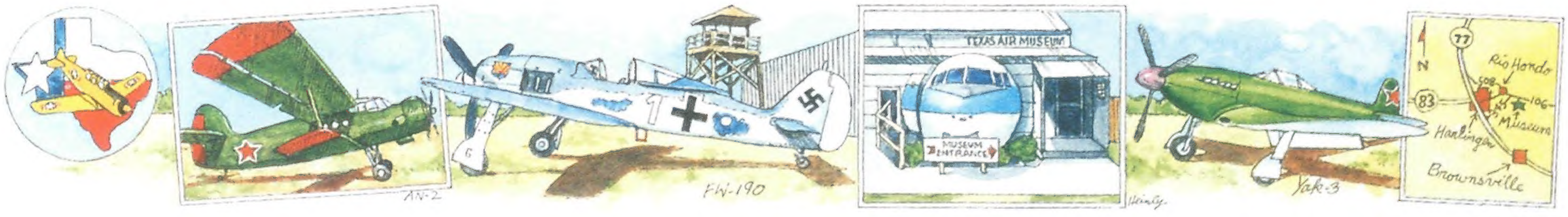
I Was in the Blockhouse! At the U.S. Army Redstone Arsenal in the 1950s, missile launch tests always drew a crowd. Under certain circumstances, the tests were very effective at dispersing a crowd as well.

The Norden Bombsight. It was considered so important to the Allied cause that World War II bombardiers took a special oath to keep it secret. Was the Norden aerial aiming device all its inventors believed it to be?

10,000 Keystrokes to Tranquillity Base. Computers made the Apollo voyages to the moon possible, but some of the tensest moments in the program were the result of bugs in the software. On a typical shuttle mission today, astronauts refer to a set of notes warning them about software "anomalies." Despite great progress in computing science and technology, glitches in programming still nettle engineers.

How I Wrote Queen Bess. Biographer Doris Rich contemplates her experiences chronicling the life of Bessie Coleman, the first black American woman pilot.

From Buffalo to the Moon. The very first ride into space started in Buffalo, New York, in November 1901, and the round-trip ticket was a mere 50 cents.



JOHN HEINLY

Home of the Yellow, White, and Blue

Unteroffizier Heinz Orlowski was in a pickle. During a fierce battle above Norway, British Beaufighters and Mustangs had raked his Focke-Wulf 190 fighter with gunfire. Just 300 feet off the deck, the young pilot faced a no-win choice: go down with his airplane or bail out well below the safe parachute altitude. Orlowski jumped, and although his parachute didn't deploy fully, he plopped into a deep snow bank and walked away with only minor injuries. His airplane, White 1, wasn't so lucky; it was severely damaged and abandoned.

Ken Brown, assistant curator of the Texas Air Museum in Rio Hondo, Texas, recounts this bit of World War II history as he stands beside the beautifully restored White 1, one of three Fw 190s in the museum's collection. A second, whose squadron call sign was Blue 4, rests beside White 1, while chunks of the third—Yellow 9—sit in restoration jigs in a nearby workshop. "This is the only place in the world with two Fw 190s on display," says Brown, who flew 50 World War II combat missions as a B-17 navigator. "We did all the restoration ourselves, and made our own replacement parts—rails, slides, canopies, everything. The plans for the Fw 190 don't exist anymore, so we even had to draw new plans based on the original parts."

The Fw 190s are the focal point of this small, friendly, eclectic museum, which nestles among the Rio Grande Valley's citrus orchards and cotton fields. World War II pilots from the United States, Great Britain, and elsewhere approach a journey to Rio Hondo as a pilgrimage, an opportunity to relive some of the most powerful moments of their lives. Says John Houston, the museum's administrator and one of its founders: "We had a guy come through a couple of weeks ago who just wanted to see the plane that shot him down."

On a recent dreary morning, light fog enfolded the complex of old and new buildings, restored aircraft, and the rusting parts in the boneyard. In Little John Hall, a hangar named after Houston's son, several directors and volunteers sat around a folding table, one of several that had been set up for a barbecue/fly-in held a few days earlier, and discussed the museum's history. The aroma of fresh coffee wafted through the humid Texas air.

Texas Air Museum, P.O. Box 70, Rio Hondo, TX 78583. Phone (210) 748-2112. Open Mon. through Sat., 9 a.m. to 4 p.m. Admission: adults $3, kids 16 and under free.

Houston explained that he and others had founded the museum in 1985 to complement the collection of the Confederate Air Force, then located in nearby Harlingen. The CAF specialized in aircraft from World War II, and the museum's founders wanted to exhibit craft from the Vietnam war. "Regardless of your political views, the people who went over there and died deserve their place in history," Houston says.

But at that time the government would not release any Vietnam artifacts to the museum, so the directors decided to expand the collection to include aircraft from World War II and the Korean war. In the last year the museum has enlarged its mandate further, including all eras of flight. The current 26-aircraft collection includes a Douglas Skyraider, a bright green Russian Yak-3, two Russian Antonov An-2 transports, and a hurricane-damaged Aerobat 1-A. Small exhibit rooms display a Norden bombsight—which someday will become a hands-on exhibit, with a simulated landscape scrolling beneath the crosshairs—and other air power artifacts.

But the museum wanted a marquee draw, and it picked the Fw 190. "It's one of the most sought-after aircraft of them all," Houston explains. "By the end of the war it was carrying the entire load for the Luftwaffe—torpedo bombing, ground support, and other missions."

Houston wrote to museums in 26 countries asking for leads on Fw 190s. One letter went to the Norwegian Armed Forces Museum. "They said not just 'no' but 'hell no; no World War II artifacts will ever leave Norway,' " recalls Houston. "I thought that was overbearing, so I fired off a snappy reply and forgot about it."

But the Norwegians didn't. Six months later they asked what Houston had in mind, and over the next couple of years, during which Houston spent a week in Norway helping restore other World War II aircraft, the groups worked out an unusual agreement: Norway would ship four battle-damaged Fw 190s to Texas, and if the museum would send one back fully restored, it could keep the other three. The museum hired three full-time machinists and artisans to renovate the Fw 190s as well as other aircraft, including a tattered Avro Anson and a P-40. Volunteers began pitching in, sometimes sleeping in guest quarters above a hangar.

From 1987 to 1992, a Norwegian air force C-130 periodically hauled in battered Fw 190 parts and returned home with restored ones. But just as important to Houston and other aviation buffs, the Norwegians provided pilot logs and other documentation for the airplanes. The staff learned, for example, that Blue 4 and White 1 went down in the same February 1945 battle, a bloody engagement Royal Air Force pilots called Black Friday. If the museum can raise enough money, it plans to restore Blue 4 into the world's only flyable Fw 190.

Last March, Heinz Orlowski, now 70, journeyed from Germany to Rio Hondo for a reunion with the fighter he last saw almost half a century ago. The encounter was filmed for the cable TV documentary program "Wings." "I was very touched and had to be careful not to weep," Orlowski told a local reporter. "It's like finding again an old friend."

With a little TLC, White 1 will remind aviation buffs of its youthful pilot—and the men who rescued it—long after they are all gone.

—Damond Benningfield

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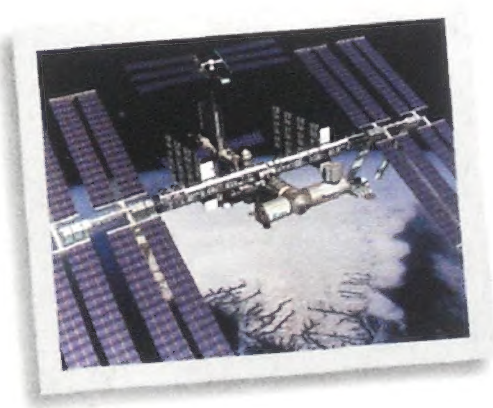

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